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MECHANICAL ENGINEERING

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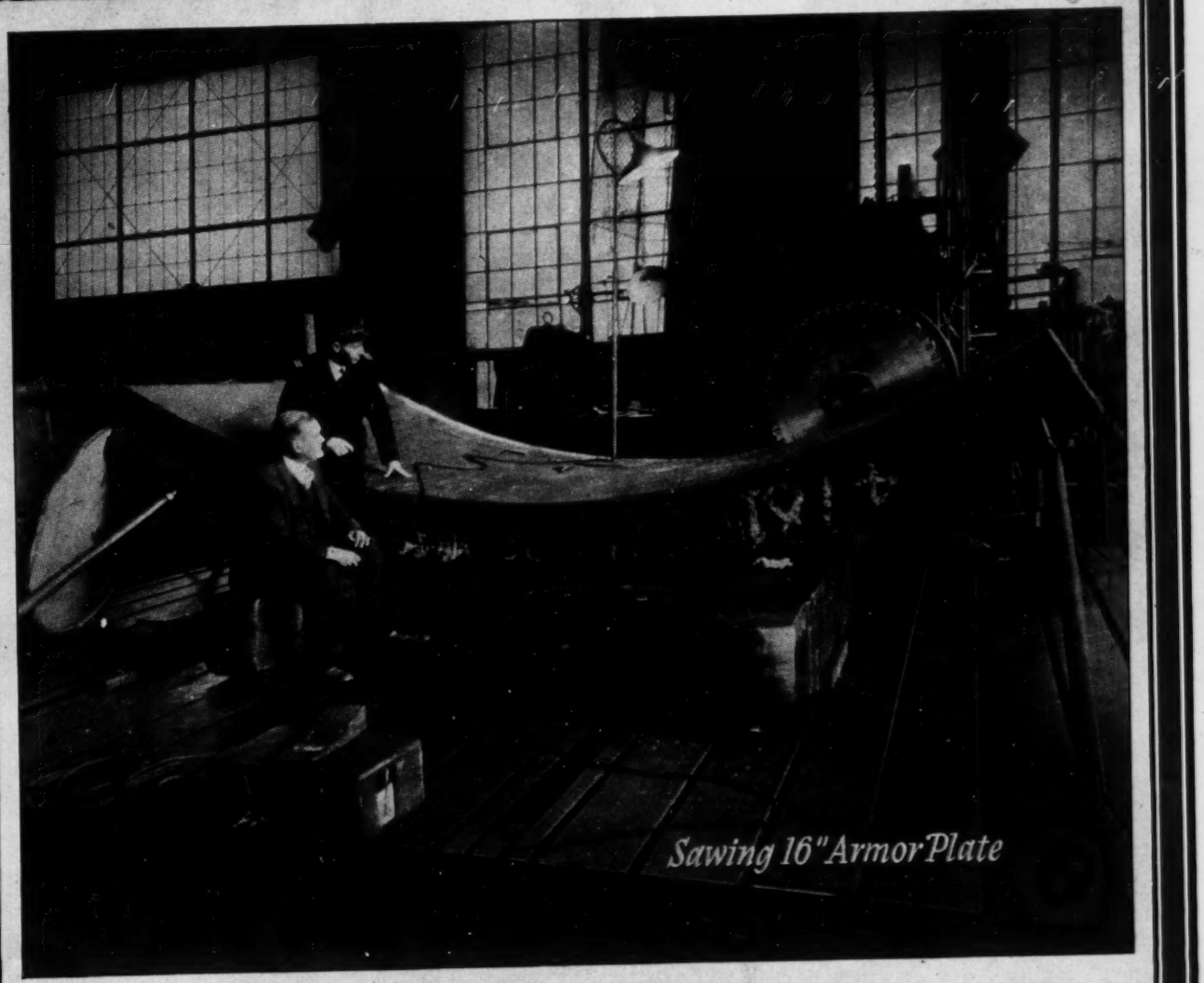

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THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

July 1930

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The Influence of Engineering

THE influence which engineering—and particularly mechanical engineering—exerts upon the world is now immeasurably great; so great, so all pervading, that we have almost lost consciousness of it, as we have of the air we breathe. It is a part of our very existence. The clothes we wear, the houses in which we live, the food we eat, are ministered to us by the mechanical engineer. We are carried to and fro about our business by his aid; the tools of the artist, the instruments of the musician, the pens, the type, the paper of the author are made by him. Our houses and our streets are lighted and heated by the machines of his hands, our amusements owe as much to him as to the performers, the equipment which we use in our sports is not free from his touch. We cannot remain in the world without his assistance, and we can scarcely leave it with decency unless he provides the means. He is the mother and father of the factory, and without it we could neither employ nor support our own people. He is the great progenitor, for without his ministrations dense populations could not be clothed, housed, fed, educated, and amused.

LOUGHNAN ST. L. PENDRED.

[From a Monograph entitled "Some Aspects of Engineering in the United Kingdom During Fifty Years," presented by the President of the Institution of Mechanical Engineers at the 50th Anniversary Celebration of the A.S.M.E., Washington, D. C., April 8, 1930.]

MECHANICAL ENGINEERING

Volume 52 July, 1930 No. 7

The Lorenzen Gas Turbine and Supercharger for Gasoline and Diesel Engines

Particulars Regarding the Design and Construction of a Gas Turbine Having a Rotor With Hollow Blades Which Are Cooled by Air Circulated Through Them Under Pressure, Together With a Discussion of Present and Possible Applications

By CHRISTIAN LORENZEN,[1] BERLIN, GERMANY

THE gas turbine works upon the same principle as the internal-combustion piston engine: after precompression of the working mixture (in the gas turbine the air and fuel are compressed separately) ignition takes place, and in the expansion that follows a part of the heat is converted into mechanical work. In the piston engine, however, work is done as the expansion progresses to the end of a stroke, whereas in the turbine the expansion of the gases and the resulting work are continuous.

The hopes held out by the gas turbine are based upon the possibility it affords of complete expansion of the gases, which is impossible in the piston engine owing to the limitations of cylinder dimensions; further, the performance capacity of a piston engine is much restricted by reason of the difficulties encountered with increased dimensions.

Just as in the piston engine, with regard to the heat supply we have to distinguish between—

a Heat supply under constant volume. The combustion takes place as an explosion under increasing pressure. The Holzwarth gas turbine works according to this method.

b Heat supply under constant pressure. The combustion takes place without an increase in pressure, as the gases can expand accordingly. The Lorenzen turbine is an example of this method.

Method *a* as compared with method *b* has two drawbacks: First, it is necessary to employ regulating or timing devices in the hot combustion chamber. Second, there is a considerably higher shock and eddy loss at the regulating valves and at the entrance edge of the turbine blades owing to the great variation of velocity in the gases. On the other hand, the thermodynamic efficiency of the explosion turbine is superior to that of the constant-pressure turbine.

In the piston engine and in general also in the gas turbine the working gases are generated inside the machine itself—in the combustion chamber in the case of the gas turbine. The turbine, however, can also work in combination with a piston engine, utilizing the energy in the exhaust gases of the latter. In recent years various turbines have been operated according to this method, notable among them being the Lorenzen exhaust-gas turbine described later in this paper.

Compared with a steam turbine, which generally has many stages, the gas turbine has but one or two working stages, owing to difficulties encountered in the materials from which it is constructed. It then operates on the constant-pressure principle, similar to the original De Laval turbine, and it is obvious that for this reason the gas turbine is at a disadvantage compared with the steam turbine. However, this difficulty will probably be overcome in time, but in comparing the two types of turbine it may be said that the exhaust from the gas turbine does not carry away as much waste heat as does that of the steam turbine, in which latter the loss in one pound of steam is 990 B.t.u.

That it has taken such a long time to develop a reliable gas turbine in spite of the many years' experience which we have had in building steam turbines, is to be ascribed to various reasons. Principally, however, as we shall see in a later portion of this paper, it is owing to the enormous stresses, both mechanical and thermal, to which the material is subjected, and to the low efficiency of the turbo-compressor—the only type of compressor that can be considered in connection with a gas turbine.

The vital question in building a gas turbine is to prevent the blades from attaining a red heat, principally at their enter-

[1] Engineer and Managing Director, Lorenzen G.m.b.H., Berlin. Mr. Lorenzen was active in early automobile developments in Germany, and went to England in 1905 for the exploitation of German designs there. When aviation started he began building airplane propellers in England. Before the World War he returned to Germany and engaged in airplane-propeller manufacture there. He participated in the earliest supercharger and adjustable-pitch aircraft-propeller developments. About the time of the Armistice he proposed a combination of adjustable-pitch propeller and exhaust-gas supercharger with automatic controls so that an airplane engine would always be charged at one atmosphere absolute pressure and its propeller pitch always adjusted to the air density where the plane was flying. The Treaty of Versailles forbade Germany to build airplanes, and so Mr. Lorenzen turned to equipping other engines with superchargers and to the development of the gas turbine. Recently he has resumed work with aircraft power plants.

Presented at the National Oil and Gas Power Meeting of the A.S.M.E. Oil and Gas Power Division, State College, Pa., June 12–14, 1930.

ing edges. Before expansion takes place the gases have a temperature of from 1000 to 1200 deg. cent. (1832–2192 deg. fahr.) and a pressure of a few atmospheres in a stationary container. To build the latter sufficiently strong to resist the pressures and temperatures involved is not a matter of great difficulty. After expansion the temperature of the gases drops about 150 to 350 deg. cent. (270–630 deg. fahr.) according to the pressure ratio employed. With a temperature drop of 150 deg. cent. a velocity of 600 meters (1968 ft.) per sec. is obtained, and with one of 350 deg. cent. (662 deg. fahr.) a velocity of about 850 meters (2790 ft.) per sec. The jet of gases now passes through and impels the blades of the fast-running turbine rotor. The peripheral speed of a single-stage rotor should, if possible, be half of the jet velocity. Fortunately, the efficiency curve of a turbine is reasonably flat near its maximum, so that with the highest possible peripheral speed a fairly good efficiency is obtainable. The centrifugal force encountered at such speeds is high even for normal temperatures, and were the turbine blades to be heated to the same temperature as the jet of gases the tensile strength of the blade material would scarcely be able to resist it.

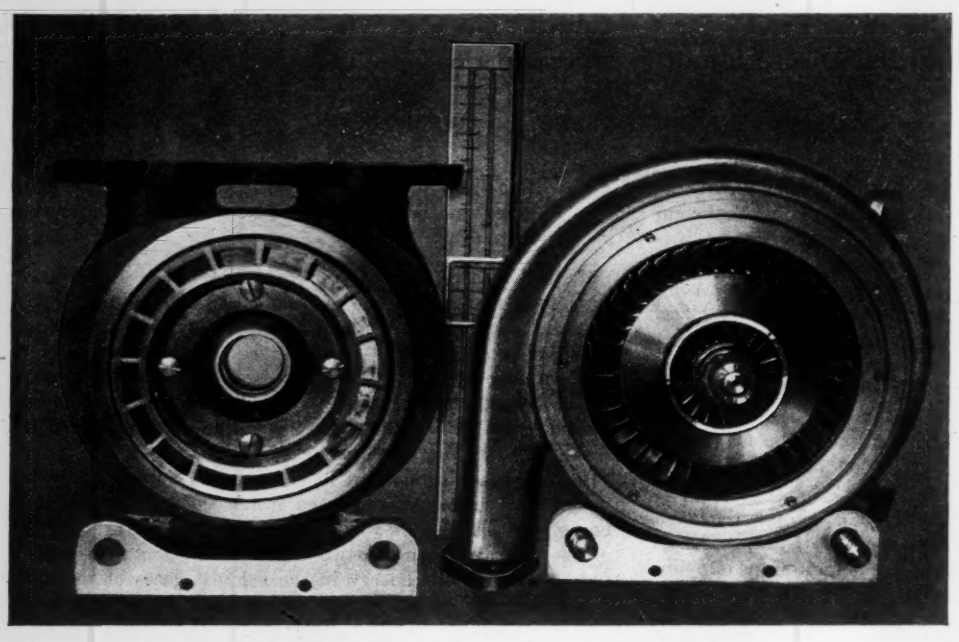

FIG. 1 SHOWING INTERIOR OF THE LORENZEN TURBINE

Water injection has been used effectively to reduce temperatures, but it has the disadvantage that most of the heat is used up in generating steam, leaving but a small amount available for work. Cooling by means of water jackets has the same disadvantage, as may be seen from the working area of the *p-v* diagram. To lower the temperature by further expansion means the application of an exhauster to create a vacuum beyond the turbine, which could only be done at the cost of efficiency. A better way, and the one which has been followed in building the Lorenzen turbine, is to overcome the difficulty by suitable construction.

THE ROTOR OF THE LORENZEN TURBINE

The construction of the rotor of the Lorenzen turbine is the same in a pure or "live" gas turbine—i.e., a turbine with its own combustion chamber and producing its own gas—as in an exhaust-gas turbine driven by the waste gases from a piston engine. Its special characteristics are as follows: [see Figs. 1 and 2]:

1 It is a single-stage impulse turbine acted upon in the axial direction by the working gases.
2 The turbine rotor acts at the same time as a compressor wheel.
3 The turbine blades are hollow, with very thin walls, and form the continuation of the compressor wheel in such a way that
4 The compressed air serves at the same time to cool the hollow blades internally by flowing in a radial direction from the inner to the outer ends.

The hollow blade which specially characterizes this turbine is the result of long years of search for a good and reliable material and the most suitable shape and form in which to dispose it. The tensile strength is about 100 kg. per sq. mm. (142,000 lb. per sq. in.) and the thickness of the wall about 0.25 mm. or 0.01 in.

That this method of cooling the turbine blades is effective may clearly be seen from the following considerations. The gases flow between the blades with a velocity of about 350 to 450 meters (1150–1475 ft.) per sec. and at a temperature of perhaps 700 deg. cent. (1292 deg. fahr.). Using accepted formulas for calculation, this gives a heat transfer of 750 kg-cal. per sq. m. per hr. per deg. cent. (154 B.t.u. per sq. ft. per hr. per deg. fahr.). To prevent the blades from becoming red hot it is also necessary that the air flowing inside the hollow blade shall have sufficient velocity so that it will carry away the heat as fast as it comes through the blade walls from the gas side. This can be effected by converting the static pressure created in the compressor wheel into velocity. For example, if the peripheral speed of the blades is about 320 meters (1050 ft.) per sec., then an air velocity of 250 meters (820 ft.) per sec. is obtainable which will cause a heat transfer of 572 kg-cal. per sq. m. per hr. per deg. cent. (117 B.t.u. per sq. ft. per hr. per deg. fahr.), and the heat flow through the wall, according to the formula

$$K = \frac{1}{\frac{1}{\alpha_G} + \frac{1}{\alpha_L}}$$

will be 324 kg-cal. per sq. m. per hr. per deg. cent. (66 B.t.u. per sq. ft. per hr. per deg. fahr.). The temperature of the hollow-blade wall will be

$$t_W = t_G - \frac{K}{\alpha_G}(t_G - t_L) = 428 \text{ deg. cent. (802 deg. fahr.)}$$

This temperature is allowable provided suitable material is used, particularly as at the most stressed part of the blade, namely, the root, the wall temperature is considerably lower owing to the reduced heating and to the better cooling obtained with the still cool air at the beginning of expansion.

THE LORENZEN TURBINE AS AN EXHAUST-GAS-TURBINE SUPERCHARGER

In an exhaust-gas turbine the impelling gases come from a piston engine and flow to the turbine nozzles. The cooling air leaving the hollow turbine blades is collected in a diffuser or volute chamber surrounding the rotor, where its velocity is converted into pressure, and it can then be used as compressed air for scavenging or supercharging the engine. The gain by this compressed air through utilization of the exhaust gases which otherwise would be wasted increases the economy and makes it possible either to increase the output of the engine or to obtain the same output with smaller cylinders.

The kinetic energy remaining in the exhaust gases leaving the piston engine may easily be determined from the p-v diagram by planimetering the hatched area $ABDEFA$ in Fig. 4, assuming the expansion line AB to be an adiabatic. A is the point at which the exhaust valve opens, and EF indicates the back pressure.

For a Diesel engine with a cylinder bore D of 500 mm. (19.68 in.) and a stroke S of 700 mm. (27.56 in.) running at 155 r.p.m. the indicated horsepower N_i (see Fig. 5) will be 188 hp., the brake horsepower N_e, 150 hp., and the theoretical energy in

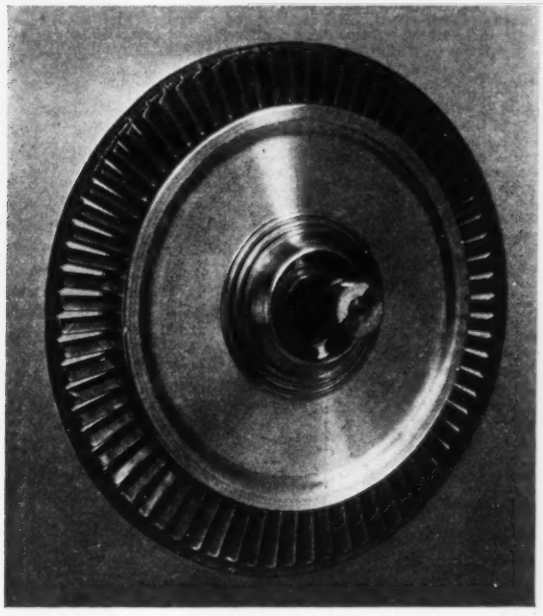

FIG. 2 ROTOR OF LORENZEN TURBINE

the exhaust gases sufficient to generate 32.2 hp. Using this energy to drive the turbine supercharger, the working diagram of the engine will be that shown at II, and the performance of the exhaust gases will be accordingly increased. Diagram IIa corresponds to a supercharge of $0.9 \times 1.25 = 1.125$ atmos. (16 lb. per sq. in.). In the factor 0.9 the losses of flow from the turbine to the cylinders have been taken into consideration, whereas diagram IIb corresponds to an overloading of $1.50 \times 0.9 = 1.35$ atmos. (19.2 lb. per sq. in.). The theoretical performance of the exhaust gases gives for IIa, 54.8 hp. and for IIb, 77.1 hp. The energy required for the compression, if assumed to be adiabatic, is 4.9 hp. in the case of IIa, and for IIb, 10.9 hp., so that the performance capacity of the exhaust gases for IIa is 11.2 times and for IIb 7.0 times the energy required for supercharging the engine.

To obtain good performance of exhaust-gas turbine superchargers in connection with multi-cylinder Diesel engines, it is proposed to attach a small turbine to each cylinder, or in smaller-sized Diesel engines one turbine to two cylinders. In the second case the inlet casing of the turbine will be divided into two halves by a wall. This will expose the nozzles to the gases of one cylinder only. The gas jet of high velocity imparts a considerable amount of energy to the turbine rotor, causing a reverse action as soon as the pressure in the cylinders is released. The turbine wheel passing the nozzles rapidly keeps up this flow and ejects the remaining gases from the cylinder which it is scavenging. If several turbines are employed, then the compressed air from the various exhaust-gas superchargers

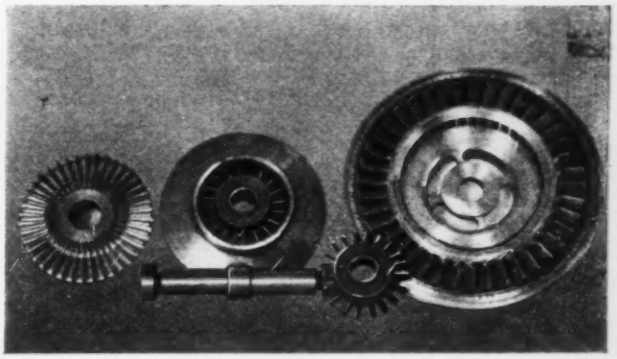

FIG. 3 COMPONENT PARTS OF THE ROTOR OF A SMALL EXHAUST-GAS TURBINE

should be led into one container. This increases the reliability of scavenging to a considerable degree, because one turbine getting out of order will not stop the delivery of air: the other turbines will simply deliver more air with a little less pressure.

One great advantage of the turbine supercharger lies in the fact that it can be attached to any existing engine without making any constructional alterations, whereas a mechanically driven supercharger requires a driving shaft with the necessary gears, clutch, etc. In applying the turbine supercharger it is only necessary to alter the run of the piping.

In practice it has been found that the application of a turbine supercharger makes the operation of an engine very flexible. The reason is that with increasing performance of the engine the output of the turbine also increases automatically, although the engine may keep on running at the same speed. This of course is impossible with a mechanically driven compressor unless a speed changer is employed.

One of these turbines was built to run at 30,000 r.p.m. During the tests it was often brought up to 40,000 r.p.m., and at the conclusion of the trials it was run up to the bursting point. At 48,000 r.p.m. measurements could still be made. When it burst it was running at about 50,000 r.p.m., this very nearly agreeing with the theoretical calculations made previously.

In this and also in later tests with larger turbines, temperatures up to 835 deg. cent. (1535 deg. fahr.) were measured ahead of the turbine and 875 deg. cent. (1607 deg. fahr.) back of it. The increase in temperature was due to incomplete combustion in the engine, and through the escape of cooling air this caused after-burning in the turbine. By taking the turbine to pieces after such tests it was found possible to determine by the color of the rotor disks and the roots of the blades that there had been a temperature of about 280 to 300 deg. cent. (536–572 deg. fahr.).

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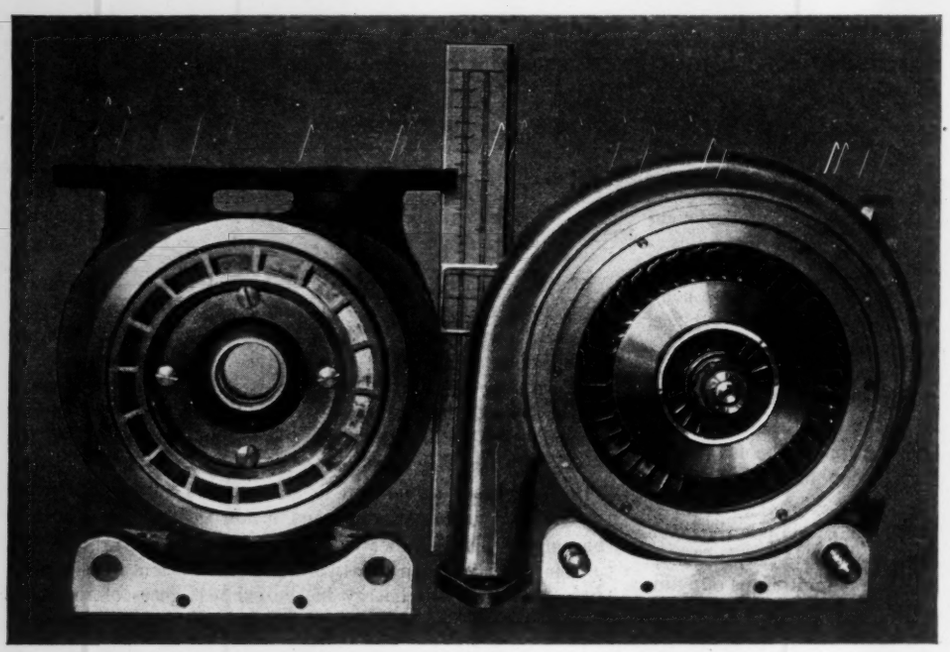

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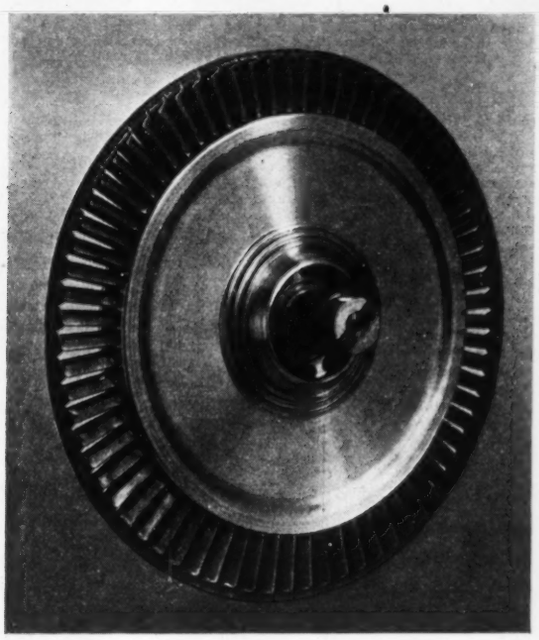

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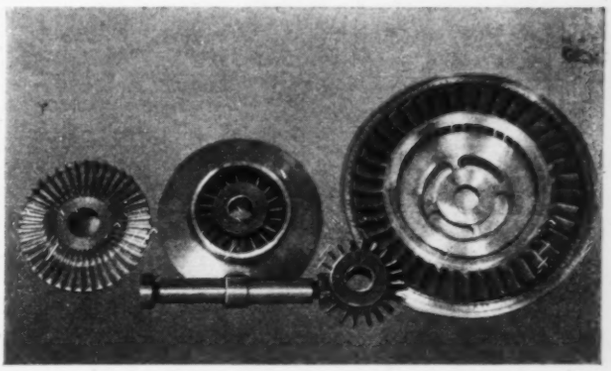


FIG. 3 COMPONENT PARTS OF THE ROTOR OF A SMALL EXHAUST-GAS TURBINE

should be led into one container. This increases the reliability of scavenging to a considerable degree, because one turbine getting out of order will not stop the delivery of air: the other turbines will simply deliver more air with a little less pressure.

One great advantage of the turbine supercharger lies in the fact that it can be attached to any existing engine without making any constructional alterations, whereas a mechanically driven supercharger requires a driving shaft with the necessary gears, clutch, etc. In applying the turbine supercharger it is only necessary to alter the run of the piping.

In practice it has been found that the application of a turbine supercharger makes the operation of an engine very flexible. The reason is that with increasing performance of the engine the output of the turbine also increases automatically, although the engine may keep on running at the same speed. This of course is impossible with a mechanically driven compressor unless a speed changer is employed.

One of these turbines was built to run at 30,000 r.p.m. During the tests it was often brought up to 40,000 r.p.m., and at the conclusion of the trials it was run up to the bursting point. At 48,000 r.p.m. measurements could still be made. When it burst it was running at about 50,000 r.p.m., this very nearly agreeing with the theoretical calculations made previously.

In this and also in later tests with larger turbines, temperatures up to 835 deg. cent. (1535 deg. fahr.) were measured ahead of the turbine and 875 deg. cent. (1607 deg. fahr.) back of it. The increase in temperature was due to incomplete combustion in the engine, and through the escape of cooling air this caused after-burning in the turbine. By taking the turbine to pieces after such tests it was found possible to determine by the color of the rotor disks and the roots of the blades that there had been a temperature of about 280 to 300 deg. cent. (536–572 deg. fahr.).

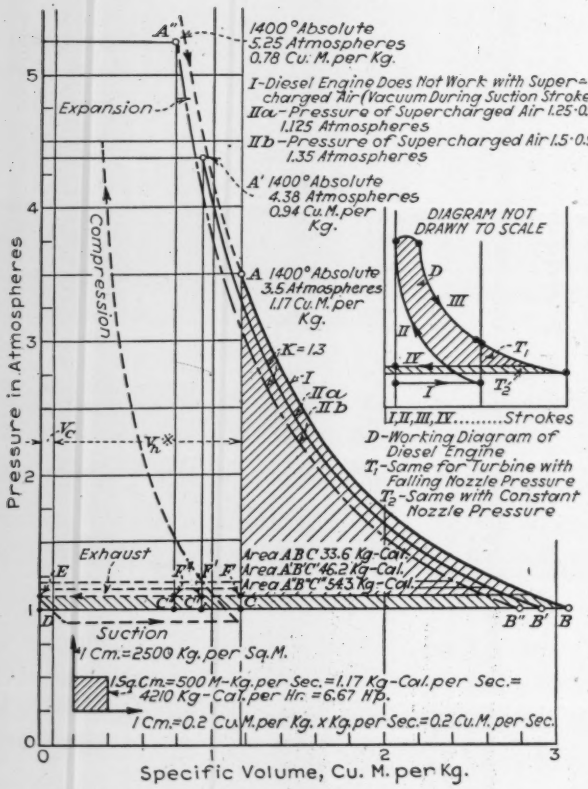

1400° Absolute
5.25 Atmospheres
0.78 Cu. M. per Kg.
I-Diesel Engine Does Not Work with Supercharged Air (Vacuum During Suction Stroke)
IIa-Pressure of Supercharged Air 1.25·0.9=1.125 Atmospheres
IIb-Pressure of Supercharged Air 1.5·0.9=1.35 Atmospheres
A' 1400° Absolute
4.38 Atmospheres
0.94 Cu. M. per Kg.
A 1400° Absolute
3.5 Atmospheres
1.17 Cu. M. per Kg.
K=1.3
Expansion
Compression
DIAGRAM NOT DRAWN TO SCALE
I, II, III, IV.....Strokes
D-Working Diagram of Diesel Engine
T1-Same for Turbine with Falling Nozzle Pressure
T2-Same with Constant Nozzle Pressure
Exhaust
Suction
Area ABC 33.6 Kg-Cal.
Area AB'C' 46.2 Kg-Cal.
Area AB"C" 54.3 Kg-Cal.
1 Cm.=2500 Kg. per Sq. M.
1 Sq. Cm.=500 M-Kg. per Sec.=1.17 Kg-Cal. per Sec.=4210 Kg-Cal. per Hr.=6.67 HP.
1 Cm.=0.2 Cu. M. per Kg. x Kg. per Sec.=0.2 Cu. M. per Sec.
Pressure in Atmospheres
Specific Volume, Cu. M. per Kg.

FIG. 4 *p-v* DIAGRAM OF TURBINE UTILIZING EXHAUST FROM A DIESEL ENGINE

THE LORENZEN TURBINE AS A PURE GAS TURBINE

The excellent results obtained with the Lorenzen rotor in exhaust-gas turbines led to its employment in a pure or "live" gas-turbine plant on a much larger scale. It was decided to build a machine according to the constant-pressure principle ("constant pressure" meaning a continuous generation of the working fluid), although the Lorenzen rotor can also be used in the explosion type of turbine. This was done to avoid the difficulties encountered by timing and regulating devices inside a hot combustion chamber. The arrangements employed are shown in Figs. 6 and 7, namely,

(*a*) Turbine and compressor combined into one rotor (Fig. 6), and

(*b*) Turbine and compressor with separate rotors (Fig. 7).

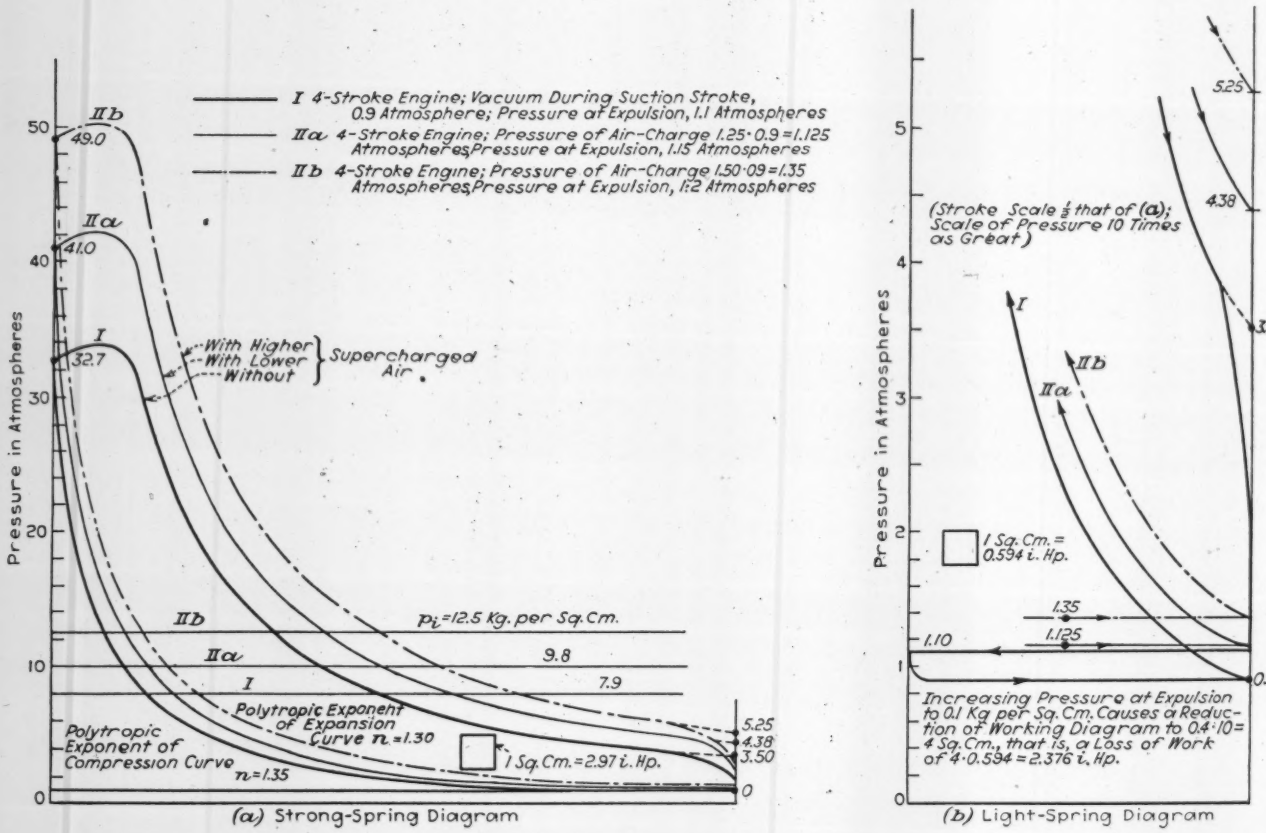
The first arrangement is only applicable for low pressures which can be obtained in one stage, whereas the second must be employed when higher pressures and larger quantities of working fluid are required.

In the first arrangement (Fig. 6) the air enters the rotor

FIG. 5 (*Below*) THEORETICAL INDICATOR DIAGRAMS OF LORENZEN TURBINE UTILIZING EXHAUST FROM A DIESEL ENGINE

(Cylinder bore, 500 mm. (19.68 in.); stroke, 700 mm. (27.56 in.); r.p.m., 155; mean piston speed, 3.62 m. per sec.; area of piston, 1964 sq. cm. (304.4 sq. in.); indicated hp. per cylinder N_i, 188 (case I); mean effective pressure p_i, 7.9 kg. per sq. cm. (112.3 lb. per sq. in.).)

	Case I	Case IIa	Case IIb
Supercharged air, atmos.	..	1.125	1.35
Ratio of air charge	~ 100	125	150
Ratio of oil burned	100	125	150
Ratio of effective output	100	125	150
Mean effective pressure, kg. per sq. cm.	7.2	9.8	12.5
Indicated hp. of one cylinder	188	233	298
Friction loss, hp.	38	45	73
Brake hp. N_i	150	188	225
Mechanical efficiency	0.80	~0.80	~0.76


I 4-Stroke Engine; Vacuum During Suction Stroke, 0.9 Atmosphere; Pressure at Expulsion, 1.1 Atmospheres
IIa 4-Stroke Engine; Pressure of Air-Charge 1.25·0.9=1.125 Atmospheres, Pressure at Expulsion, 1.15 Atmospheres
IIb 4-Stroke Engine; Pressure of Air-Charge 1.50·09=1.35 Atmospheres, Pressure at Expulsion, 1.2 Atmospheres
49.0
41.0
32.7
With Higher
With Lower
Without
Supercharged Air
pi=12.5 Kg. per Sq. Cm.
9.8
7.9
Polytropic Exponent of Expansion Curve n=1.30
Polytropic Exponent of Compression Curve n=1.35
1 Sq. Cm.=2.97 i. Hp.
5.25
4.38
3.50
Pressure in Atmospheres
(a) Strong-Spring Diagram
(Stroke Scale ½ that of (a); Scale of Pressure 10 Times as Great)
1 Sq. Cm.=0.594 i. Hp.
1.35
1.125
1.10
0.9
Increasing Pressure at Expulsion to 0.1 Kg per Sq. Cm. Causes a Reduction of Working Diagram to 0.4·10=4 Sq. Cm., that is, a Loss of Work of 4·0.594=2.376 i. Hp.
(b) Light-Spring Diagram

at *a*, flows through the compressor and the hollow blades, its high velocity then being converted into pressure in a volute chamber or diffuser surrounding the rotor. This compressed air is then led into a heat exchanger of special construction (Fig. 8) which has been in use for about two years in the Berlin municipal gas works and operates exceptionally well because of the continuous internal rotation of the air and gases flowing. After flowing through the heat exchanger the air is led into the combustion chamber, where sufficient fuel is added to obtain the desired temperature. As the combustion chamber is open toward the turbine nozzles, the same constant pressure exists inside it as in the compressor—less, of course, the loss in the heat exchanger. The gases now expand in the nozzles of the turbine and impel the hollow blades of the turbine rotor, after which they pass into the heat exchanger where they give up their remaining heat to the compressed air.

The second arrangement (Fig. 7) differs from the first, a special compressor being employed. The cooling air may then

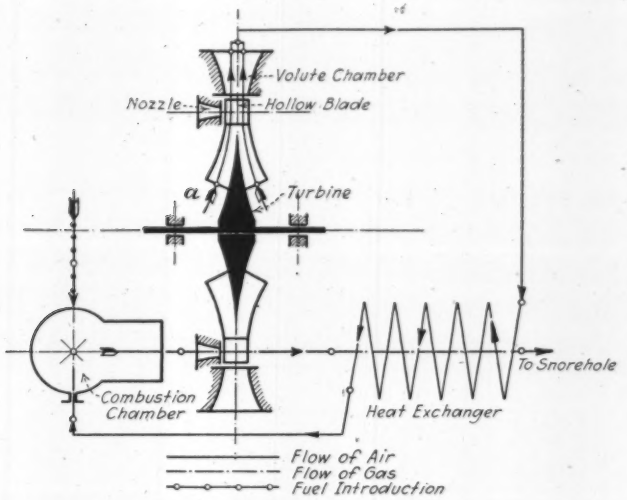


FIG. 6 COMBINED TURBINE AND COMPRESSOR ROTOR

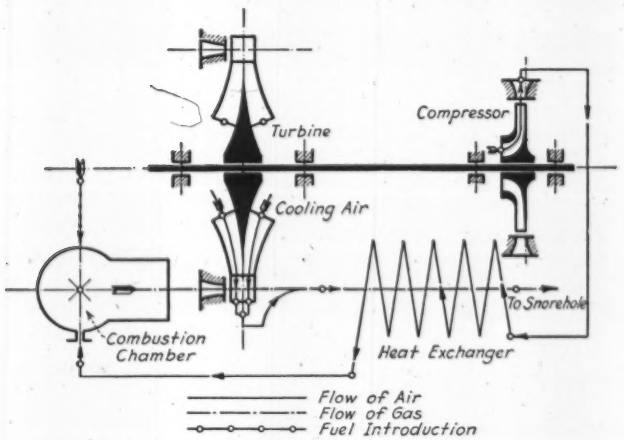


FIG. 7 TURBINE AND COMPRESSOR ROTORS SEPARATE

be used for heating purposes or led under a boiler or the like. The highest efficiency is obtained when the cooling air is applied as described in the first arrangement in a special combustion chamber with lower pressure and its own sectional portion of nozzles.

That it is necessary to utilize the heat remaining in the exhaust when a high efficiency is to be obtained, can easily be seen from the entropy diagram in Fig. 9, which has been drawn to scale for a special example. In this drawing *ABCDA* represents the quantity of heat added through fuel supply, and *AEFGHKA* the turbine performance after deducting the work required for the compressor and the cooling air. The heat re-

FIG. 8 SPECIALLY DESIGNED HEAT EXCHANGER

maining in the exhaust is shown by the area *LMNOL*. The relation of the area *AEFGHKA* to *ABCDA* gives the thermal efficiency when the heat remaining in the exhaust is not utilized. In order to regain the greatest possible amount of heat from the exhaust for use in the turbine plant, a heat exchanger may be considered. How far this is feasible depends only on the size and the efficiency of the heat exchanger. If, for example, we allow a difference of 100 deg. cent. (180 deg. fahr.) between gas and air and the turbo-compressed air comes from the compressor at 125 deg. cent., we can then easily raise its temperature to 600 deg. cent. (1112 deg. fahr.) in the heat exchanger. In the combustion chamber it is desired to bring this temperature up to 1000 deg. cent. (1832 deg. fahr.), so it is necessary to add fuel according to the area *APQDA*, making the thermal efficiency the ratio of the area *AEFGHKA* to *APQDA*, or $\eta_{th} = \sim 29$ per cent for the example in question.

The curves of Fig. 11 show the relationship between amount of fuel, size of heat exchanger, and thermal efficiency at various pressures and temperatures at the nozzles in a gas-turbine plant of 7500 kw., assuming that the gases impelling the hollow blades have a temperature of 750 deg. cent. (1382 deg. fahr.) and a constant peripheral speed of 320 meters (1050 ft.) per sec. The isothermal efficiency of the turbo-compressor is $\eta_{is} = 72$ per cent, as the loss of pressure in the heat exchanger is assumed to be 0.15 atmos. (2.13 lb. per sq. in.). The plant then shows an

efficiency of about $\eta_{th\,max} = \sim 31$ per cent when the working fluid is at a pressure of $p = 3.5$ atmos. (45.8 lb. per sq. in.). The effect of a rise in temperature is very great—for example, an increase of 100 deg. cent. increases the total efficiency about 5 per cent.

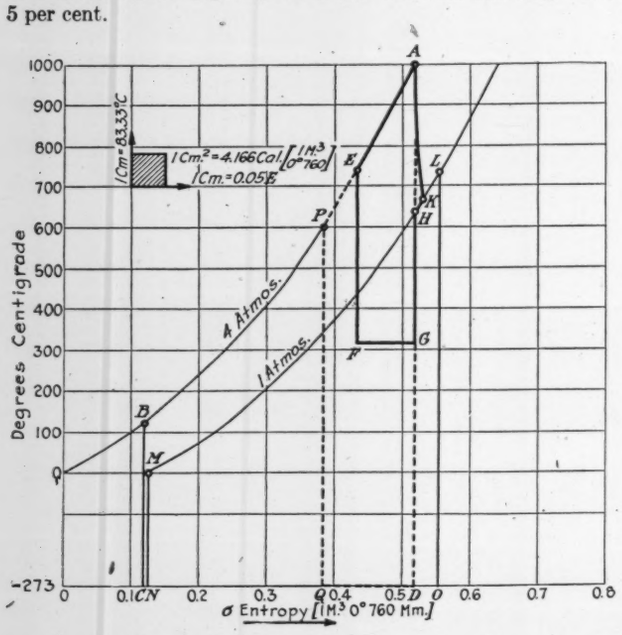


FIG. 9 ENTROPY DIAGRAM FOR A SPECIAL CASE

It may be said that in these curves the utilization of the cooling air by the hollow blades has not been taken into consideration; on the other hand, the area of the heat exchanger, which has been calculated as an ordinary straight-run exchanger, will be considerably reduced by using the spiral form shown in Fig. 8.

Fig. 10 shows a pure (or "live") gas turbine in the course of assembly. At the center is the rotor, its diameter being 990 mm. (38 in.); behind it at the right the inlet casing and the nozzles, both entirely built out from the special Krupp steel NCT3; and at the left the outlet casing, which is welded up from V2A Krupp steel. In addition both casings are enclosed in a sheet jacket, the space between casing and jacket (3 to 4 in. wide) being filled with firebrick ground to about pea size and put under pressure through a pipe connecting with the compressor. This arrangement protects the outer jacket from the combustion heat and the inner casing from pressure.

Fig. 12 shows the entire plant. Regulating devices are necessary only for the intake to the compressor and for the fuel supply, and these are of the same types as those used with other compressors or steam boilers.

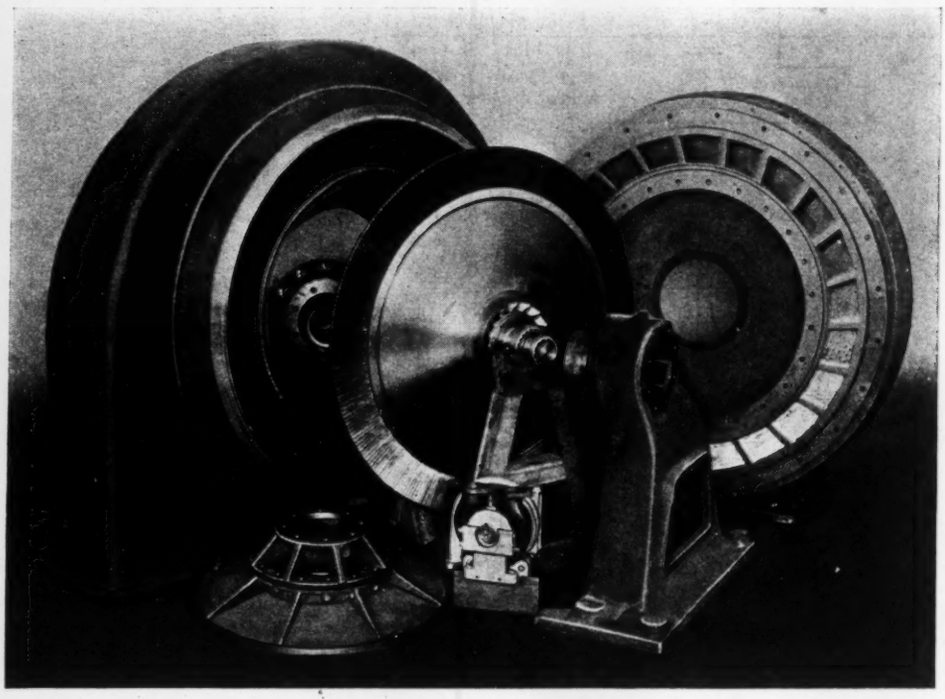


FIG. 10 ASSEMBLY OF PURE GAS TURBINE WITH 38-IN. ROTOR

FUTURE POSSIBILITIES

Another method of utilizing the heat in the exhaust and one which shows the highest efficiency is the following: When the compressed air is not preheated by the exhaust, its temperature must be raised from 125 deg. cent. up to about 1000 deg. cent. (257 to 1832 deg. fahr.) by the fuel supply. Owing to the limitation of the temperature to about 1000 deg. cent. (1832 deg. fahr.) the combustion takes place with about three times as much air as is necessary and the exhaust from the turbine with a temperature of about 700 deg. cent. (1292 deg. fahr.) contains sufficient oxygen to bring its temperature up to 1400 to 1500 deg. cent. (2552–2732 deg. fahr.) by adding fuel. This is high enough to be used under a steam boiler or in melting metals in foundries or the like. If the heat remaining in the exhaust is fully utilized in this way, then the turbine plant will show an efficiency of more than 85 per cent.

The combination of a gas turbine with a steam-turbine plant may be of special interest in municipal electric plants or in ship propulsion, and particularly in battleships, because the gas-turbine plant is ready at any moment to start, and would have sufficient power to set the ship in motion. A steam-turbine plant able to utilize fully the exhaust from a gas turbine will have an output about double that of the gas-turbine plant. The space required for the gas-turbine plant in such a combination would be inconsiderable.

In gas works, coke plants, foundries, etc., there is a great waste of heat. With the aid of the Lorenzen turbine this heat can also be saved to a great extent, inasmuch as it may be transferred to compressed air coming from the turbine, and then employed therein to do mechanical work. The temperature of this waste heat largely ranges from 400 to 600 deg. cent., 750–1100 deg. fahr.) A constant-pressure-turbine plant, however, first begins to work when the temperature of the working fluid exceeds 500 deg. cent. (932 deg. fahr.), and at first glance it would seem that little could be done. But remembering that

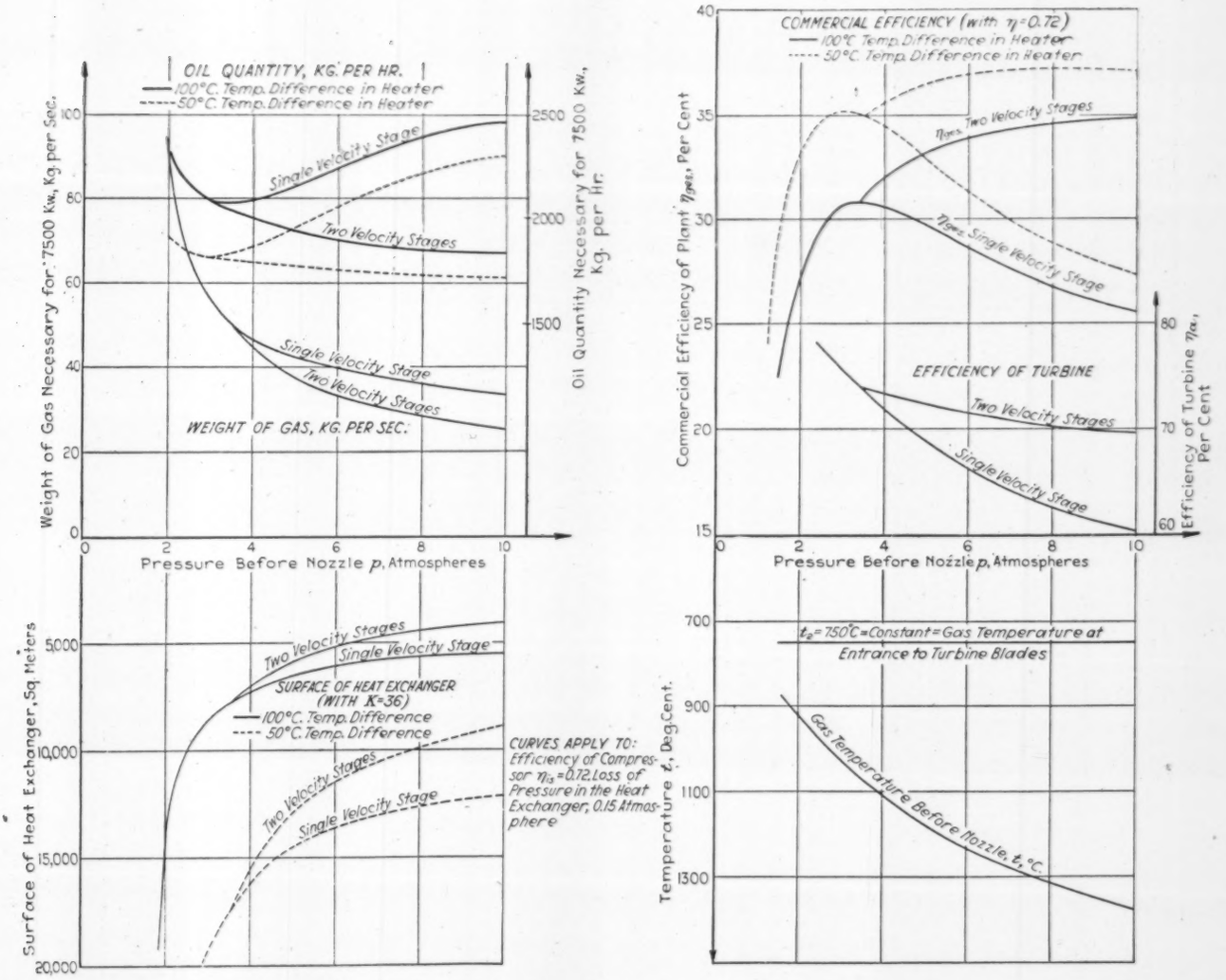

OIL QUANTITY, KG. PER HR.
100°C. Temp. Difference in Heater
50°C. Temp. Difference in Heater
Single Velocity Stage
Two Velocity Stages
WEIGHT OF GAS, KG. PER SEC.
Weight of Gas Necessary for 7500 Kw., Kg per Sec.
Oil Quantity Necessary for 7500 Kw., Kg. per Hr.
Pressure Before Nozzle p, Atmospheres
SURFACE OF HEAT EXCHANGER (WITH K=36)
100°C. Temp. Difference
50°C. Temp. Difference
CURVES APPLY TO: Efficiency of Compressor η_{ic}=0.72, Loss of Pressure in the Heat Exchanger, 0.15 Atmosphere
Surface of Heat Exchanger, Sq Meters
COMMERCIAL EFFICIENCY (with η=0.72)
100°C. Temp. Difference in Heater
50°C. Temp. Difference in Heater
η_{pas} Two Velocity Stages
η_{pas} Single Velocity Stage
EFFICIENCY OF TURBINE
Two Velocity Stages
Single Velocity Stage
Commercial Efficiency of Plant η_{pas}, Per Cent
Efficiency of Turbine η_{ic}, Per Cent
t_2=750°C=Constant=Gas Temperature at Entrance to Turbine Blades
Gas Temperature Before Nozzle, t_1, °C.
Temperature t_1, Deg. Cent.

FIG. 11 EFFICIENCY, FUEL REQUIREMENTS, HEAT-EXCHANGER SURFACE, ETC., OF A 7500-KW. GAS-TURBINE PLANT FOR VARIOUS PRESSURES AND TEMPERATURES AT THE NOZZLES

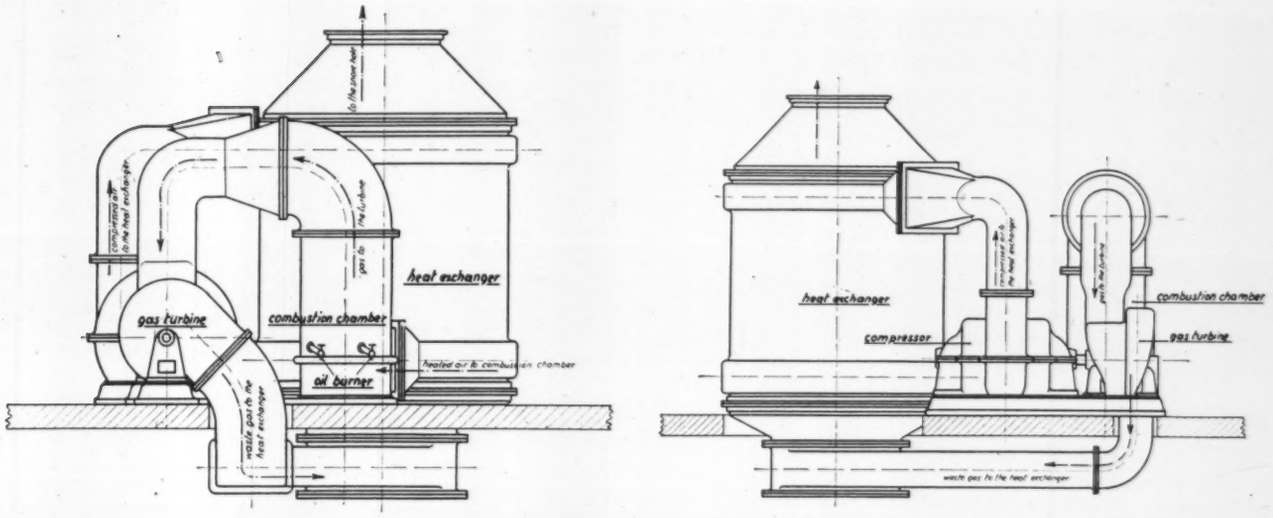


FIG. 12 ARRANGEMENT OF PLANT IN WHICH TURBINE OF FIG. 10 IS INSTALLED

the heat from the exhaust of the turbine is still available, the method shown in Fig. 13 can be employed. Most gas ovens make use of a recuperator in which the secondary air is preheated to about 600 to 800 deg. cent. (1112–1472 deg. fahr.). This preheating is done by the waste gases coming from the retorts. When leaving the retorts these gases are at about 900 to 1000 deg. cent. (1652–1832 deg. fahr.) and are cooled down to 400 to 600 deg. cent. (752–1112 deg. fahr.) in passing through the recuperator. If now these gases are led into a heat exchanger through which compressed air is driven in the opposite direction,

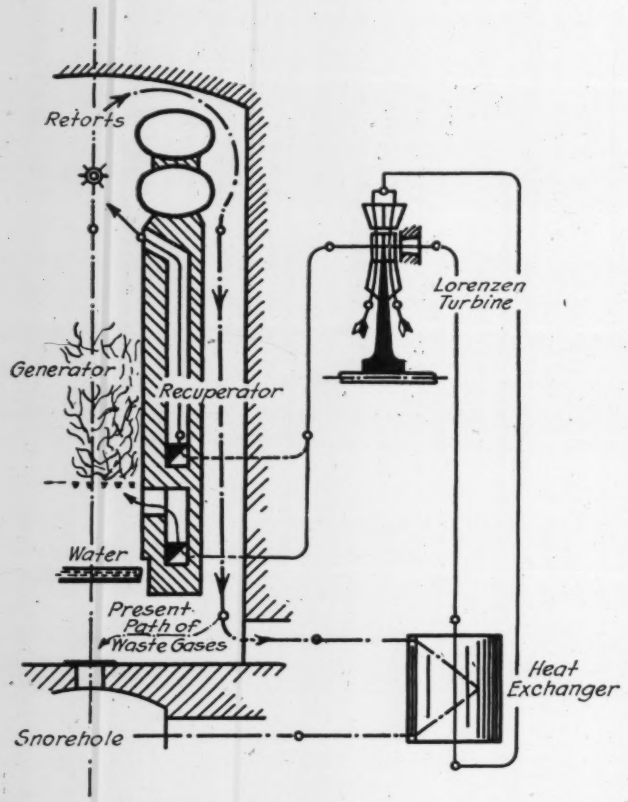


FIG. 13 ARRANGEMENT FOR UTILIZING WASTE GASES FROM GAS PLANTS

then the temperature of the latter will be raised to 300 to 500 deg. cent. (572–932 deg. fahr.) on their way to the nozzles of the turbine. Owing to the low pressure and low temperature of the air, the drop in temperature will only be slight; however, the exhaust air with its remaining heat is now led to the intake of the secondary air, say, at 300 deg. cent. (572 deg. fahr.), and as it is already partly heated it therefore cannot absorb so much heat from the waste gases. The result is that the latter will now enter the heat exchanger at 600–700 deg. cent. (1112–1292 deg. fahr.) and the compressed air will accordingly be more highly heated and the exhaust air will also have a higher temperature. By circulating the heat the temperature of the waste gases when leaving the recuperator is gradually raised to a point at which mechanical work can be done. This is the method of operating when the turbine is added to existing gas ovens which have recuperators. In new ovens the recuperator can be omitted altogether, and the waste gases after leaving the retort chamber can be led directly to the special heat exchanger. The waste gases having more than double the weight of the secondary air, it is obvious that an equal weight of compressed fresh air may be heated; the other half can then be led as primary air into the gas generator, or may be used under a boiler to generate steam. In a battery of ovens consuming 35 tons of fuel per day, the energy developed is in the first case about 200 hp., beside which there is a saving of fuel; and in the second case when a steam plant is installed, it is about 500 hp. continuously.

From these few examples, which of course could be considerably added to, it will be seen that the Lorenzen turbine is applicable over a range extending from the motor car, flying machine, Diesel engine, locomotive, and ships, up to the largest power stations, and can be operated as an exhaust-gas turbine, a pure gas turbine, or as a hot-air turbine.

In conclusion the author desires to express his sincere thanks to Prof. Fr. Schäff, of Nuremberg, who has been his scientific assistant during the whole development for about fourteen years, and to his son, Max Lorenzen, who has constructed all the turbines shown in the photographs.

The Centenary of Fourier

TWO YEARS before Carnot published his famous essay "Réflexions sur la Puissance Motrice du Feu," the well-known memoir of Fourier, "Théorie Analytique de la Chaleur," was printed. Carnot's essay was the outcome of the young engineer's study of the steam engine; Fourier's was the work of a mathematician deeply interested in physical problems. Both memoirs have long been regarded as among the classics of science, and both have had far-reaching effects, but it is not without interest to recall that for many years Carnot's views were almost unheeded, while Fourier's work, before being printed, was allowed to lie for ten years among the archives of the Paris Academy of Sciences. Fourier's first paper on the theory of heat dates from 1807. The subject was, however, proposed for a prize, to be decided in 1812, and it was for this that the "Théorie Analytique" was written. Its final appearance in 1822 gave science one of its masterpieces. Fourier's methods, wrote Maxwell, "belong to the general theory of the application of mathematics to physics; for in every branch of physics, when the investigation turns upon the expression of arbitrary conditions, we have to follow the method which Fourier first pointed out in his "Theory of Heat."

Jean Baptiste Joseph Fourier was born at Auxerre, on March 21, 1768, and died in Paris, at the age of 62, on May 16, 1830, a hundred years ago. Though in after years he played many parts successfully, it is as a mathematician that he is remembered. His career covered the days of the Revolution, the Consulate, the Empire, and the Restoration. An ardent republican, he weathered the storms of the Terror, and then joined the staff of the École Polytechnique. From Paris he accompanied Napoleon to Egypt, where he was one of the most active and intelligent administrators, but one who, when busily engaged with antiquities, munitions, and public affairs, could yet find leisure for mathematical studies. Back in France in 1802, he was made Prefect of the Department of Isère, and was as interested in the draining of marshes as in the propagation of heat. In 1816 he was given an appointment in Paris, and in 1822 succeeded the astronomer Delambre as perpetual secretary to the Paris Academy of Sciences. With the mind of a student he combined the best characteristics of a public servant and the eloquence of an orator. He it was who stimulated the youthful imagination of the Egyptologist, Champollian; he was among the first to appreciate the value of Ampère's work, and for his *éloges* on Delambre, Charles, and Herschel he was elected to a chair in the French Academy. France has produced many administrators who have been eminent in science, but few more generally respected than Fourier.—*Engineering*, May 23, 1930, p. 675.

Economic Considerations in the Application of Modern Steam Turbines to Power Generation

A Discussion Comprising Comments on Current Practice; Data on Costs, Floor Space, and Economic Performances; and Analyses of Reheating Problems and of the Economic Rating of Turbine Casings

By A. G. CHRISTIE,[1] BALTIMORE, MD.

THIS paper will outline some economic considerations which justify the application of modern steam turbines for power generation in central stations and in industrial plants.

The economic bases for the application of modern steam turbines to power generation may be either rate of growth of power load, low first cost, low operating cost, low maintenance, savings in operating labor, high thermal efficiency, large reliability and availability factors, great concentration of power on a small floor area, small volume of power plant required to house these units, or capability of construction in the largest sizes that are now demanded.

Operating conditions vary greatly due to the use of different steam pressures, temperatures, exhaust conditions, and use factors,[2] to variations in the cost of fuel, and to modifications of the heat cycle of the plant. These differences result in diversity of plant design and in the selection of turbines which are suited in each case to the local conditions. Substantially the same ultimate result may be secured by several different arrangements of turbines, boilers, and other apparatus. A discussion of the economic bases for the justification of each such arrangement is beyond the limits of this paper. Certain comments on current practice, data on costs, floor space, and economic performances, together with an analysis of the problems of reheating and of the economic rating of turbine casings, will be presented.

The efficiency of a given type and size of turbine is regulated by competition and by advances in the art of design and construction. No manufacturer furnishes the most efficient turbine that he is capable of building, with the possible exception of certain large and special units. Each builder will supply at the current market price a turbine of about the same thermal efficiency as his competitors. This condition leads to low turbine prices but does not always insure that the most economical turbine is furnished, considering both efficiency and fixed charges.

Since another paper[3] read at this Conference illustrates the practice in turbine construction of the General Electric Company, this paper will show some representative turbines of other American manufacturers. Acknowledgment is made to the engineers of the Allis-Chalmers Manufacturing Company, Westinghouse Electric & Manufacturing Company, General Electric Company, Elliott Company, Terry Steam Turbine Company, De Laval Steam Turbine Company, and Moore Steam Turbine Company, for data, illustrations, information, and other assistance furnished for the preparation of this paper.

I—LARGE STEAM TURBINES

Economic Justification

Large steam turbines for the purpose of this paper are those exceeding 5000 kw. capacity. Such units, on account of their economic advantages, are used almost exclusively in all but the smaller central stations. It would have been next to impossible to meet the power requirements that now exist in large electrical systems with reciprocating, gas, or Diesel engines. The development of the large steam turbine has been stimulated more by the demand for capacity than for improved efficiency, although satisfactory gains in economy have been achieved with increase in size. Among present-day prime movers, dependence must therefore be placed on large modern steam turbines to meet growing power demands.

The trend of steam-turbine development in America has been progressively toward units of large capacity. Table 1 gives data on recent American installations. Fig. 1 shows the progress in operating conditions of one turbine builder over a period of years.

Large units are warranted by the rapid growth of power systems, many of which have doubled their output in the last seven years. In 1928 there were 135 systems in the United States, 14 in Canada, and 3 in Mexico, each of which had outputs of over 100,000,000 kw-hr. during the year. Of these systems, 27 in the United States and 5 in Canada generated over 1,000,000,000 kw-hr. apiece in 1928. The peak loads on these 32 systems varied from 178,000 kw. to 1,125,000 kw. Such figures indicate the magnitude of many American power systems. The average rate of increase in output of these systems is about 10 per cent per year. The need for large steam turbines in many American central stations is apparent.

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[1] Professor of Mechanical Engineering, The Johns Hopkins University. Mem. A.S.M.E. Professor Christie has served in his present capacity on the faculty of Johns Hopkins University since 1924. He was graduated from the school of Practical Science of Toronto University in 1901. He then became connected with the Westinghouse Machine Co. and later was for a year an instructor in mechanical engineering at Cornell University. For two years he was with the Allis-Chalmers Co., then becoming mechanical engineer with the Western Canada Cement & Coal Co. The next six years he taught at the University of Wisconsin. He is a well-known consulting engineer and has conducted many investigations both here and abroad on power plants and their equipment.

[2] The term "use factor," as employed in this paper, is the ratio of the total annual output in kilowatt-hours, to the normal rating of the turbine in kilowatts multiplied by the total hours per year, i.e., 8760.

Presented at the Second Plenary World Power Conference, Berlin, Germany, June 16–25, 1930.

[3] "Recent and Possible Future Developments Affecting the Economics of Large-Steam-Turbine Practice in the United States," by G. B. Warren.

TABLE 1 NEW TURBO-GENERATOR UNITS OVER 60,000 KW. IN OPERATION OR UNDER CONSTRUCTION

Kw. capacity, manufacturer[1]	Operating company and station	Type,[2] r.p.m., and volts			Steam conditions—remarks
208,000, G.E.	State Line Generating Co., Chicago, Ill.—State Line	C.C.,	1800,	22,000	600 lb.—reheating
165,000, W.	United Electric Light & Power Co., New York, N. Y.—Hell Gate	C.C.,	1800,	13,800	265 lb., 700 deg. fahr.
165,000, G.E.	Ohio Power Co., Philo, Ohio—Philo	C.C.,	1800,	11,000	600 lb.—reheating
160,000, B.B.	United Electric Light & Power Co., New York, N. Y.—Hell Gate	C.C.,	1800,	13,800	275 lb., 610 deg. fahr.
160,000 G.E.	New York Edison Co., New York, N. Y.—East River	T.C.,	1500,	11,400	275 lb., 700 deg. fahr.
115,000 A.C.	Public Service Co. of Northern Illinois, Waukegan, Ill.—Waukegan	T.C.,	1800,	18,000	625 lb., 750 deg. fahr.—reheated to 750 deg. fahr.
110,000, W.	Brooklyn Edison Co., New York, N. Y.—Hudson Avenue	C.C.,	1800,	13,800	400 lb., 706 deg. fahr.
104,000, W.	Commonwealth Edison Co., Chicago, Ill.—Crawford Avenue	C.C.,	1800,	12,800	550 lb.—reheating
94,000, G.E.	Southern California Edison Co., Los Angeles, Calif.—Long Beach No. 3	T.C.,	1500,	16,500	400 lb., 725 deg. fahr.—two units
91,500, G.E.	Commonwealth Edison Co., Chicago, Ill.—Crawford Avenue	C.C.,	1800,	12,000	550 lb.—reheating
75,000, G.E.	Buffalo General Elec. Co., Buffalo, N. Y.—Chas. R. Huntley	S.,	1500,	12,000	250 lb., 660 deg. fahr.
75,000, G.E.	Union Electric Light & Power Co., St. Louis, Mo.—Cahokia	S.,	1800,	13,800	315 lb., 725 deg. fahr.
65,000, G.E.	Edison Electric Illuminating Co., Boston, Mass.—Edgar	S.,	1800,	14,000	350 lb., 725 deg. fahr.
65,000, A.C.	Public Service Co. of Northern Illinois, Waukegan, Ill.—Waukegan	T.C.,	1800,	18,000	600 lb., 725 deg. fahr.—reheating to 725 deg. fahr.
64,000, W.	Northern Indiana Public Service Co., Michigan City, Ind.—Michigan	S.,	1800,	22,000	650 lb., 750 deg. fahr.
63,000, G.E.	Columbia Power Co., Cincinnati, Ohio—Columbia	T.C.,	1800,	13,200	600 lb.—reheating; 45,000-kw. unit rebuilt
	NEW HIGH-PRESSURE UNITS				
110,000, G.E.	Ford Motor Co., Detroit, Mich.—River Rouge	S.C.,	1800,	13,800	1200 lb., 750 deg. fahr.—steam reheating
55,000, G.E.	New Jersey Power & Light Co., Dover, N. J.—Holland	C.C.,	3600, 1800	13,800	1200 lb.—reheating
53,000, G.E.	American Gas & Electric Co., New York, N. Y.—Deepwater (N. J.)	C.C.,	3600, 1800	11,000	1200 lb.—reheating
53,000, G.E.	American Power Corp., Philadelphia, Pa.—Deepwater (N. J.)	C.C.,	3600, 1800	11,000	1200 lb.—reheating
52,500, G.E.	Pacific Gas & Elec. Co., San Francisco, Calif.—Station A	C.C.,	3600, 1800	12,000	1200 lb., 750 deg. fahr.—reheating
25,000, G.E.	Jersey Central Power & Light Co., South Amboy, N. J.—South Amboy	S.C.,	3600, 1800	13,200	1200 lb., 750 deg. fahr.—reheating
12,500, G.E.	American Gas & Electric Co., New York, N. Y.—Deepwater (N. J.)	S.,	3600,	11,000	1200 lb.—exhausted at 450 lb.

[1] G.E.—General Electric Co. W.—Westinghouse Elec. & Mfg. Co. B.B.—American Brown Boveri Co. A.C.—Allis-Chalmers Mfg. Co.
[2] S.—Single-cylinder. T.C.—Tandem compound. C.C.—Cross-compound. S.C.—Steeple compound.

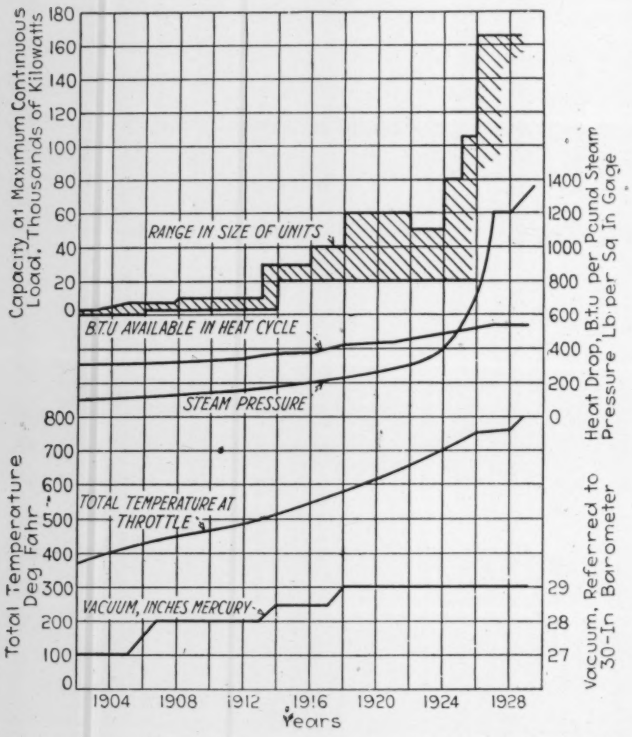
Capacity at Maximum Continuous Load, Thousands of Kilowatts
RANGE IN SIZE OF UNITS
B.T.U AVAILABLE IN HEAT CYCLE
STEAM PRESSURE
TOTAL TEMPERATURE AT THROTTLE
VACUUM, INCHES MERCURY
Total Temperature Deg Fahr
Heat Drop, B.t.u. per Pound Steam Pressure Lb per Sq In Gage
Vacuum, Referred to 30-In Barometer
Years

FIG. 1 PROGRESS IN OPERATING CONDITIONS FROM 1902 TO 1929
(From construction data of Westinghouse Elec. & Mfg. Co., South Philadelphia, Pa.)

Large turbines can be built for higher engine efficiencies[4] than smaller units, and this leads to lower operating costs. Fig. 2 shows the gain in efficiency of two notable turbines built four years apart by the Westinghouse Electric & Manufacturing Co.

Several factors influence the choice of capacity in a new turbine. Rate of load growth of a given system at times indicates that certain sizes of units should be installed as required by the increasing demand. Too small units would in many cases necessitate too frequent plant additions. Too large a unit may require operation at low use factors when first installed.

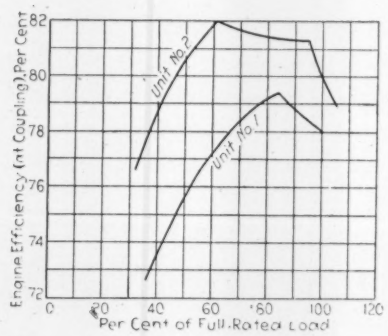

FIG. 2 COMPARISON OF SINGLE-CYLINDER CENTRAL-STATION-TURBINE EFFICIENCIES
(From data furnished by Westinghouse Elec. & Mfg. Co., South Philadelphia, Pa.)

Unit No. 1—Purchased in 1924. 40,000-kw. single-cylinder, for Cahokia Station, St. Louis, Mo. Most efficient load, 84 per cent of rating. Operating conditions: 300 lb. per sq. in. gage, 670 deg. fahr., 29 in. vacuum, with multiple-flow low-pressure blading. Annulus of last row of blades, 84.0 sq. ft.

Unit No. 2—Purchased in 1928. 60,000-kw. single-cylinder, for Lakeside Station, Milwaukee, Wis. Most efficient load, 62 per cent of rating. Operating conditions: 290 lb. per sq. in. gage, 700 deg. fahr., 29 in. vacuum, with straight reaction low-pressure blading. Annulus of last row of blades, 83.1 sq. ft.

Duplicate units in a station are sometimes preferred. The advantages of this arrangement are interchangeability of parts in case of trouble, and small investment in spare parts. As the operating reliability of turbines increases, these advantages become of less value. Since additions to a plant are generally made over a period of years, the last of such duplicate turbines added generally lacks the improvements in design that have developed since the station was first planned. Units of the current design at the time of each extension and often of progressively increasing size and efficiency are usually installed in American stations. Fig. 3 shows the improvement in performance of five turbines furnished consecutively to the same central station by the Allis-Chalmers Manufacturing Company over a period of eight years. The constant rate of heat consumption of No. 5 unit over a wide range of load is characteristic of the trend of design in large turbines.

[4] The term "engine efficiency" as used in this paper is the term adopted by The American Society of Mechanical Engineers for that factor otherwise known as the "efficiency ratio referred to the Rankine cycle." Engine efficiency is defined as the ratio of the heat turned into work at the coupling or at generator terminals per pound of steam supplied, to the heat available per pound from adiabatic expansion on the Rankine cycle from initial steam conditions before the throttle valve to exhaust pressure.

The capacity of a new unit should be such that in case of outage the remaining units of the system can safely carry the load. Recent practice indicates that the size of new units varies between one-sixth and one-fourth of the system's total capacity.

BASE-LOAD TURBINES

New turbines are sometimes added to power systems to carry base loads. The economics of such an addition to a growing system may sometimes be questioned, for in practice the base load is transferred in turn to the newest and more economical machine. The use factor of an original unit which may have been intended for base load, thus becomes progressively less and less with each addition to the system.

Turbines are now generally selected on the basis of the average annual use factor over their working life rather than on high use factors that may only be obtained during the first years of service. However, certain systems have become so large that the constant portion of the load through the twenty-four hours forms a base load of some magnitude. The construction of a highly efficient steam station of the latest design, or the addition of certain base-load units in one of the stations, may then be justified to carry this portion of the load.

PEAK-LOAD TURBINES

Serious consideration has of late been given to the question of peak loads. Should new turbines be selected to take the base load of the system, thus relegating the older units to operation at lower use factors and peak-load service, or may savings be effected by adding units of lower first cost which are specially designed for peak-load service? While the Ruths steam accumulator with its turbines has been used abroad for peak-load service, it has not yet been installed in America for this purpose.

American engineers, rather than to use special turbines, prefer to install units that are available at all times for steady operation so that they may serve in emergencies in place of one of the main units. They believe that added furnace volume is the cheapest method of providing additional steam-generating capacity in a plant for peak-load service. The short duration of peak loads makes boiler operation at high ratings an economical procedure from the point of view of total cost of power. The availability of high-pressure steam from such boilers at the time of peak loads favors the installation of high-pressure turbines with extra capacity above the most economical load to utilize this steam.

Some interesting units of large capacity have been installed with this object in view. The United Electric Light and Power Company, of New York, N. Y., has one unit of 165,000 kw. capacity and a second of 160,000 kw. in their Hell Gate Station. The point of best efficiency on these turbines ranges from 95,000 to 110,000 kw. and they are generally run as base-load units at these ratings. The load on each machine may increase to 145,000 kw. on daily peaks, and to the full rated capacity during the annual peak or in emergencies.

The new 75,000-kw. unit at Cahokia Station of the Union Electric Light & Power Company, St. Louis, Mo., is another interesting case. This station was first put into operation in October, 1923, with two 35,000-kw. units, and its capacity was progressively increased to 195,000 kw. by installing additional turbines, the last of which has 50,000 kw. capacity. A hydroelectric plant became part of the system, and a second hydroelectric station is under construction. The Cahokia Station in the future must furnish power supplementary to the hydroelectric plants, together with variable amounts of base-load power, and vice versa in later years after all available hydroelectric energy is utilized to best advantage under the conditions then existing. When a further addition became necessary, it was decided to remove the first 35,000-kw. unit with its condenser to another plant of the system and to install on the same foundations in Cahokia a new 75,000-kw. turbine-generator and condenser. This is the largest single-cylinder turbine that has been built for 1800 r.p.m. Its most economical load is at 52,500 kw.; the remaining capacity is available for peak loads and emergencies. Its steam consumption in B.t.u. per kilowatt-hour is less than the unit that it replaced. The furnaces were rebuilt under the boilers installed with the original 35,000-kw. turbine, and these boilers now furnish the steam necessary for the 75,000-kw. unit.

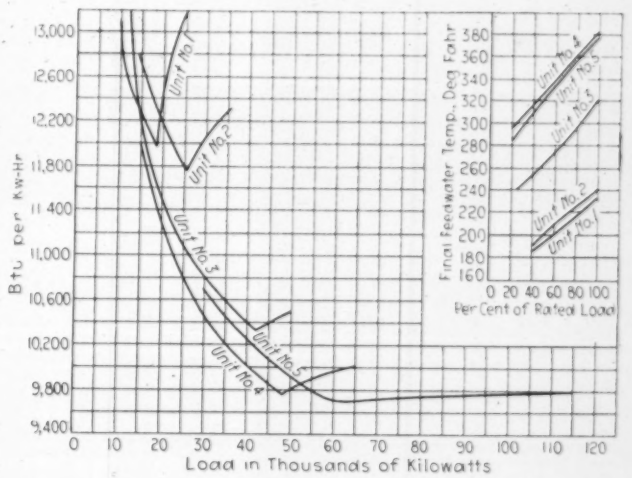

FIG. 3 IMPROVEMENT IN STEAM-TURBINE PERFORMANCE—THE ECONOMY CHARACTERISTICS OF A SERIES OF FIVE UNITS INSTALLED AND BUILDING FOR A TYPICAL AMERICAN CENTRAL STATION DURING A PERIOD OF EIGHT YEARS

(From data furnished by Allis-Chalmers Mfg. Co., Milwaukee, Wis., Final feedwater temperatures at various per cents of rated load are also shown.)

Unit No. 1.—25,000 kw. at 93 per cent power factor. Operating conditions: 350 lb. per sq. in. gage, 675 deg. fahr., 29 in. vacuum, 2-stage bleeding. Installed in 1923.

Unit No. 2.—35,000 kw. at 93 per cent power factor. Operating conditions: 350 lb. per sq. in. gage, 675 deg. fahr., 29 in. vacuum, 2-stage bleeding. Installed in 1925.

Unit No. 3.—50,000 kw. at 85 per cent power factor. Operating conditions: 600 lb. per sq. in. gage, 725 deg. fahr., 29 in. vacuum, 4-stage bleeding. Installed in 1927.

Unit No. 4.—65,000 kw. at 85 per cent power factor. Operating conditions: 600 lb. per sq. in. gage, 725 deg. fahr., 29 in. vacuum, reheat to 725 deg. fahr., 4-stage bleeding. Installed in 1930.

Unit No. 5.—115,000 kw. at 95 per cent power factor. Operating conditions: 625 lb. per sq. in. gage, 750 deg. fahr., 29 in. vacuum, reheat to 750 deg. fahr., 4-stage bleeding. To be installed in 1931.

A third example is Unit No. 5, Fig. 3. Its most efficient load is 62,000 kw., but it can operate at little increase in heat consumption in B.t.u. per kw-hr. up to its rated capacity of 115,000 kw.

ECONOMIC TURBINE DATA

Certain data on modern turbines which will assist in their economic selection are presented in Figs. 4 to 7. These curves indicate the savings that may be expected in floor space, weight, and operating and first costs through the use of large units.

RESERVE CAPACITY

The use of large units in power systems of moderate size may be questionable when due consideration is given to reserve. A single large unit may be so expensive that adequate reserve to replace its outage is not provided. This leads to operating difficulties when an outage would cripple the service of the system. In such a case a smaller-sized unit with adequate reserve would be preferable.

The size of the necessary reserve cannot be determined by any fixed rules. Enough capacity in the same or in other interconnected stations should be held in reserve to carry the load in case of outage of the largest unit. This reserve margin is sometimes sacrificed to a considerable extent at the time of maximum annual

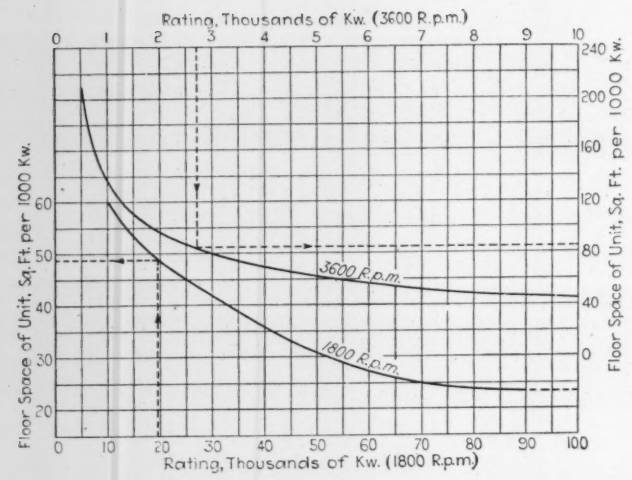
Rating, Thousands of Kw. (3600 R.p.m.)
Floor Space of Unit, Sq. Ft. per 1000 Kw.
Floor Space of Unit, Sq. Ft. per 1000 Kw.
3600 R.p.m.
1800 R.p.m.
Rating, Thousands of Kw. (1800 R.p.m.)

FIG. 4 FLOOR SPACE REQUIRED FOR SINGLE-CYLINDER 3600-R.P.M. TURBINE-ALTERNATORS AND ALSO FOR SINGLE-CYLINDER 1800-R.P.M. UNITS

(This area consists of a rectangle enclosing turbine, generator, and direct-connected exciter, with an added rectangle for any offset valve gear.)

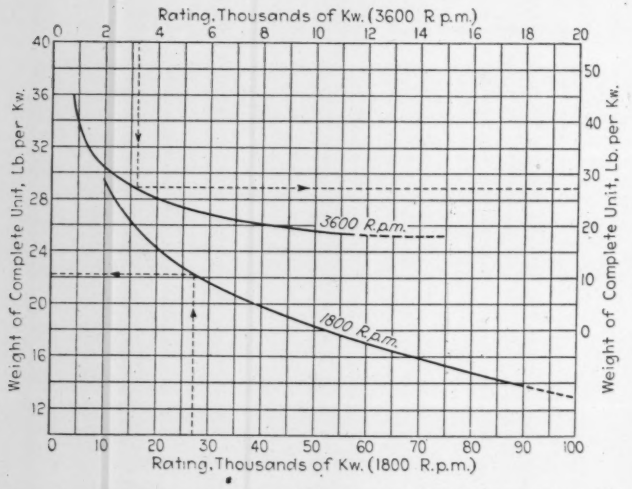
Rating, Thousands of Kw. (3600 R.p.m.)
Weight of Complete Unit, Lb. per Kw.
Weight of Complete Unit, Lb. per Kw.
3600 R.p.m.
1800 R.p.m.
Rating, Thousands of Kw. (1800 R.p.m.)

FIG. 5 WEIGHTS OF SINGLE-CYLINDER 3600-R.P.M. TURBINE-GENERATORS AND OF 1800-R.P.M. UNITS

peaks where these are sharp and of short duration. Much has been written about the advantages of interconnection as a means of reducing reserve capacity by pooling such capacity between the interconnected systems. This is possible in some interconnections, but in many cases there is not sufficient diversity of load between adjoining power systems to warrant a large interchange of power. Hence interconnections are generally limited in capacity. As a result of improvements in service availability and reliability, most American systems now carry equipment in reserve to the extent of 20 to 25 per cent of the system demand.

AVAILABILITY AND RELIABILITY

Availability for service and reliability when in service are important factors in the economic selection of a turbine. The unit should be available for service during the greatest number of hours per year. An outage from any cause during periods of demand necessitates the installation of reserve capacity, and this results in additional investment, with added fixed charges to be carried by the system output. The reliability of a turbine-generator should be such that it can continue to operate satisfactorily under adverse load conditions and will not be subject to sudden and unexpected failures. Central-station engineers sacrifice some measure of efficiency to secure rugged and dependable turbines. Refinements in design which may lessen dependability are subject to critical study before they are incorporated in new units.

The operating performances of all large units in America have been recorded and carefully studied by the Prime Movers Committee of the National Electric Light Association, which publishes such data periodically in its "Report on Steam Turbines." These data indicate that the availability of large turbines is improving, as shown by the 1928–29 Report, where the availability factor of 207 turbines of 20,000 kw. capacity and above averaged 90.31 per cent. The major causes of turbine outages are blade troubles. Present developments in the design and construction of blades give promise of a probable reduction in outages from this cause.

Such performance figures are reassuring to purchasers of steam

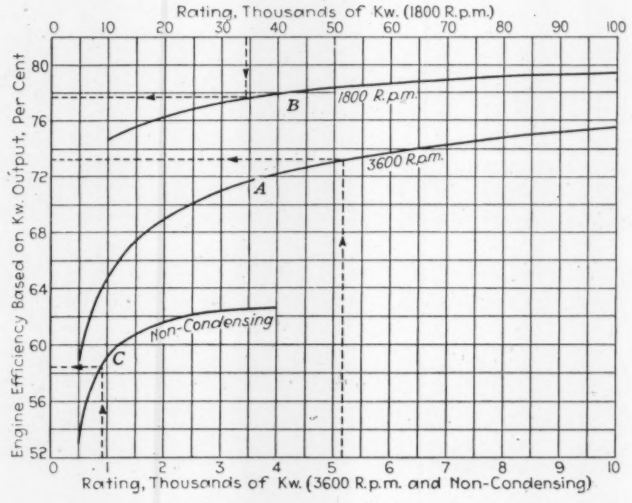

FIG. 6 AVERAGE ENGINE EFFICIENCY FOR THE LOAD POINT OF BEST EFFICIENCY BASED ON KILOWATT OUTPUT AT THE GENERATOR TERMINALS

Curve *A*—Single-cylinder turbines at 3600 r.p.m. for steam conditions up to 300 lb. per sq. in. gage, 600 deg. fahr., 28.5 in. vacuum.
Curve *B*—1800-r.p.m. turbines for steam conditions up to 450 lb. per sq. in. gage, 750 deg. fahr., 29 in. vacuum.
Curve *C*—Non-condensing units for steam conditions up to 250 lb. per sq. in. gage, 550 deg. fahr., atmospheric pressure at exhaust.

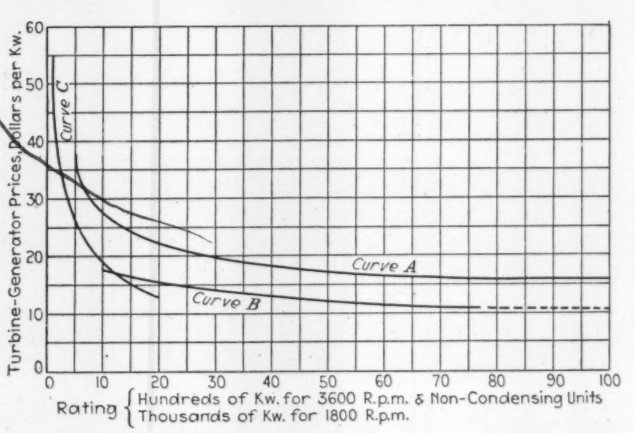

FIG. 7 PRICES FOR TURBINE-GENERATOR UNITS IN THE UNITED STATES

(Prices include bare turbine and generator without auxiliary generators or direct-connected exciters, and are for units delivered and erected. Prices are for pressures up to 400 lb. per sq. in. gage, steam temperatures up to 725 deg. fahr. and when condensing, up to 29 in. vacuum.)

Curve *A*—3600 r.p.m., condensing units.
Curve *B*—1800 r.p.m., condensing units.
Curve *C*—Small non-condensing sets.

turbines. During the period covered by the N.E.L.A. data, higher steam pressures and temperatures have been used, units of large size have been built, and blade speeds have increased. In spite of all these changes, which unquestionably introduce difficulties in construction and operation, the skill of designers has been equal to the demands placed upon them, and the average performance factors have increased.

STEAM PRESSURES AND TEMPERATURES

The choice of the most economical steam pressure and temperature to use in a new turbine plant presents a difficult problem of the highest importance. The question is whether the savings in fuel resulting from the employment of higher steam pressures and temperatures are sufficient to offset the increased fixed charges on high-pressure equipment.

Opinions of American engineers have been at variance regarding the cost of plants using pressures of 1200 lb. per sq. in.[5] and above. The first installations with these high pressures were expensive, as all equipment in these early plants carried high development charges. Such equipment was only justified by assuming that the plant would carry base loads at high use factors.

Standardization of parts and improvements in design have substantially reduced the cost of high-pressure equipment. The lowered heat consumption, through the use of high initial steam pressure and temperature with reheating, has lessened the size of boilers, furnaces, coal-burning equipment, condensers, and condenser auxiliaries, so that the total cost of a plant for 1200 to 1500 lb. per sq. in. pressure at the present time is said not to exceed that of a 450-lb. plant by more than 5 per cent. This difference will continue to decrease and 1500-lb. plants will eventually cost no more, or at most very little more, than one at the lower pressure. Turbine plant aggregating nearly 500,000 kw. is in operation or under construction in America for pressures of 1200 lb. per sq. in. and above.

A large number of turbines are now in operation in America at pressures above 450 lb. per sq. in. Users of turbines operating at 500 to 600 lb. per sq. in. report that in general no troubles have been due to high pressure. These turbines are now run under regular service conditions, though units with flue-gas reheating require more careful handling than turbines operating at lower pressures.

Some minor troubles developed on the first designs of turbines operating with pressures of 1200 lb. per sq. in. which were corrected on later units. Other difficulties have not been inherent in the turbine. For instance, at Milwaukee trouble was encountered with deposits on the blades due to improper control of the boiler concentration. Operators of 1200-lb. turbines state that there is no more difficulty in handling them in regular service than in operating standard units.

Turbines for 1200 lb. and over are compounded with a high-pressure element, generally of a high-speed type, which exhausts through a reheater into a slower-speed low-pressure section. Multiple-valve control gear has been used on some recent high-pressure elements to improve the water rate of the whole set at partial loads.

Tests indicate that in large turbine units the high-pressure section receiving steam at 1200 lb. per sq. in. can be designed to give nearly as high engine efficiency as its low-pressure section, and that compound units can be built to give overall engine efficiencies of 78 per cent, based on kilowatt output.

Initial steam temperatures in America have not in general exceeded 750 deg. fahr. With this temperature limit, increases in initial steam pressure above 450 lb. per sq. in. with modern high-efficiency turbines result in excessive quantities of moisture at the last blades of the turbine. Rapid erosion of metal takes place and the efficiency of the unit, initially decreased by the presence of the moisture, is further lessened by the eroded blading. Outages for replacement of blading are serious and expensive. Engineers are therefore limiting the moisture content of exhaust steam to 10 per cent in order to lessen these troubles. Either increased steam temperatures or interstage reheating should be employed with pressures of 500 lb. or higher if moisture at exhaust is not to exceed 10 per cent. Data on the gains from increased temperature, and on the higher steam pressures that may be used with increased steam temperatures without exceeding 10 per cent wetness at exhaust, have already been presented by various authors.

The rapid decrease in the tensile strength of ordinary steels at temperatures above 750 deg. fahr., together with troubles from "creep," have made engineers question the use of such steels at these higher temperatures. Recent experiences with certain alloy steels now warrant their safe use at high temperatures. It is proposed to allow such stresses in the design of turbines for high temperature that "creep" will not exceed one one-hundredth of 1 per cent per year.

Increased steam temperature tends to increase the cost of superheaters, main steam piping, and the high-pressure section of the turbine. This increase is a small portion of the total plant cost and is partially offset by the savings in the boiler capacity required. The total increase in cost, even if special alloys are used, should be less than the cost of reheaters. It would appear that increased plant economy may be obtained by increased temperatures together with high pressures at a lower total cost than by the employment of reheaters, and also that the use of higher superheat will lead to a simpler station.

The possibilities of high-temperature plant operated on a simple regenerative cycle are to be investigated by the Detroit Edison Company, who are installing a 10,000-kw. two-cylinder tandem turbine-generator in their new Delray No. 3 plant at Detroit, Mich. The steam conditions for this unit will be 365 lb. per sq. in., 1000 deg. fahr. Based on experiences with high steam temperatures in other industries, this plant should prove successful and its performance should lead to a general increase in steam temperatures in new central stations. Several designs of plants to use steam temperatures of 825 and 850 deg. fahr. are already being considered.

REHEATING AND REGENERATIVE FEEDWATER HEATING

Reheating of the steam at some intermediate stage in its expansion has been employed on most turbines operating with pressures above 500 lb. per sq. in. In some cases a special boiler is provided with a reheater incorporated in the boiler setting, to which the steam is returned for reheating by the flue gases, usually to the initial steam temperature. This involves much piping and results in pressure losses.

Live-steam reheaters have been employed in certain installations in order to simplify piping and to lessen first cost. The temperature leaving such a reheater is lower than the initial steam temperature. Live-steam reheating at 600 lb. per sq. in. results in a gain of less than 2 per cent over operation without reheaters. Best results are obtained at 600 lb. when the steam is reheated at 10 to 20 per cent of the initial pressure.

A combined system of reheating is employed in some new American stations in which the steam is first passed through a live-steam reheater and then raised to a still higher temperature in a second superheater by the flue gases of a reheat boiler. The supply of live steam to the first reheater is thermostatically

[5] Steam pressures in pounds per square inch are all "gage pressures," i.e., pressures above the barometric pressure, unless otherwise specifically stated. Vacuum is stated in inches of mercury referred to a 30-in. barometer.

controlled to maintain a constant steam temperature leaving the flue-gas reheater.

No fundamental difficulties have developed with reheating by flue gases. Live-steam reheaters are still undergoing development. The principal objections to reheating are the additional first cost of plant, the resulting piping complications, the pressure loss through the reheater, and the greater care necessary in the operation of reheat boilers and turbines.

The continuous demand for turbines of large size to meet growing loads, concentrated the attention of designing engineers on increased capacity of units rather than on increased efficiency. The regenerative cycle, though it had been used for a long time on American pumping engines, was not applied to steam turbines until recent years. Its thermal advantages are now generally recognized, and it is employed on all large and many small turbines to obtain better station economies. Usually the evaporator system to furnish distilled make-up water for boiler feed, forms a portion of the bleeder system. Steam for the evaporator is taken from one of the bleeder points and the evaporator condenser is used to heat the feedwater, or one of the lower bleeder heaters is used as an evaporator condenser. Distilled make-up water in new stations has been a steadily decreasing percentage of the total steam through less blowdown from the boilers due to tighter condenser tubes, and from less leakage at turbine glands due to the almost universal use in America of water seals at all points where spindles leave the casings. The principal loss of steam in the cycle of a modern plant is through the soot blowers. Long Beach Station, Long Beach, Calif., and State Line Station, State Line, Ind., are said to require only 0.5 per cent make-up. A usual allowance in selecting evaporators is $1^1/_2$ to 2 per cent of the total steam to the turbine as make-up.

The number of bleeder heaters employed varies from two to five. Additional extraction heaters above three can only be economically justified where use factors, fuel costs, or both, are high. More bleeder heaters are added when air preheaters alone are used than when an economizer is installed. The possible gains in thermal efficiency through the use of different numbers of extraction heaters have been fully discussed in other papers.

The design of bleeder heaters and their connecting pipes is not standardized. An analysis of a number of recent tests indicates considerable variation in performance. The pressure drop from the extraction point to the bleeder heater varies from 3 per cent on high-pressure heaters to 10 per cent on the lowest-pressure heater. When the bled steam is highly superheated, the feedwater in some new installations leaves the bleeder heater at temperatures 2 to 20 deg. fahr. above the saturation temperature corresponding to the pressure in the bleeder heater. Experience has shown that, contrary to early ideas, it is economical to bleed superheated steam from the turbine to heat feedwater. With saturated steam the terminal difference between the feedwater and the steam in the heater varies from 5 to 10 deg. fahr. Water velocities in heater tubes vary from 4 to 6 ft. per sec., with pressure drops through the heater of 4 to 12 lb. per sq. in. Heat-transfer rates vary from 400 to 700 B.t.u. per sq. ft. per hr. per deg. fahr. of arithmetical mean temperature difference; the higher transfer rates are found in high-pressure bleeder heaters when the water velocities in the tubes are high.

If it were possible to remove all the moisture in the flowing steam at each bleeder point, the efficiency of the low-pressure sections of the turbine would be improved and blade erosion decreased. Such moisture exists in the steam as minute droplets, like fog, although these droplets are concentrated to some extent by centrifugal force at the moving blade tips. Some new turbines have drainage grooves to remove a portion of this moisture, and tests indicate that some gains in efficiency and in decreased erosion resulted from such construction. This factor is of sufficient economic importance to warrant further study and development.

AN ANALYSIS OF REHEATING

The improvement in economy to be expected from reheating has been set forth by different writers; for instance, by Blowney and Warren.[6] In general these estimates and actual performances, have shown a gain due to reheating for initial steam pressures at 600 lb. and higher of 6 to 8 per cent. It has been stated

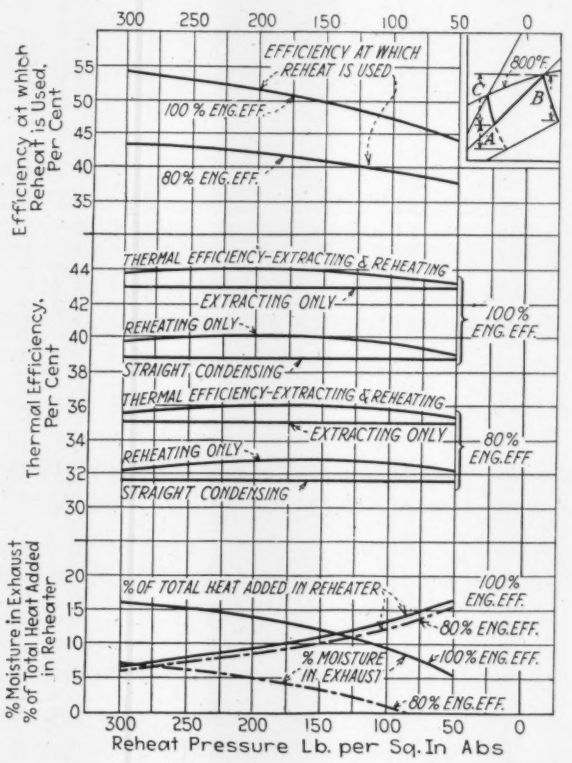
Efficiency at which Reheat is Used, Per Cent
EFFICIENCY AT WHICH REHEAT IS USED
100% ENG. EFF.
80% ENG. EFF.
800°F.
Thermal Efficiency, Per Cent
THERMAL EFFICIENCY-EXTRACTING & REHEATING
EXTRACTING ONLY
REHEATING ONLY
STRAIGHT CONDENSING
100% ENG. EFF.
80% ENG. EFF.
% Moisture in Exhaust % of Total Heat Added in Reheater
% OF TOTAL HEAT ADDED IN REHEATER
% MOISTURE IN EXHAUST
100% ENG. EFF.
80% ENG. EFF.
Reheat Pressure Lb. per Sq. In Abs

FIG. 8 AN ANALYSIS OF REHEATING WITH INITIAL CONDITIONS OF 600 LB. PER SQ. IN. ABS., 800 DEG. FAHR., AND REHEATING AT VARIOUS PRESSURES TO 800 DEG. FAHR., WITH FINAL EXPANSION TO 29 IN. VACUUM FOR AN IDEAL TURBINE OF 100 PER CENT EFFICIENCY AT COUPLING AND FOR ONE WITH 80 PER CENT ENGINE EFFICIENCY

(No allowance made for reheat factors, moisture correction, or pressure drop through reheater.)

Thermal efficiency

$$= \frac{\text{Work done in high-pressure section + work done in low-pressure section}}{\text{Heat added by boiler and by reheater above heat of liquid at feed temperature}}$$

Efficiency at which reheat is used

$$= \frac{\text{Work from steam after reheating—work between same pressures with no reheating}}{\text{Heat added in reheater}}$$

$$= \frac{B - A}{C} \text{ in Mollier diagram in upper corner of figure}$$

Per cent total heat added in reheater

$$= \frac{\text{B.t.u. added in reheater}}{\text{B.t.u. added in boiler above heat of liquid at feed temperature + B.t.u. added in reheater}}$$

that a large part of this gain has resulted from the improvement of turbine efficiency in the low-pressure stages.

However, there has been no general statement made covering an analysis[7] of the heat added during the reheat operation. In

[6] "The Increase in Thermal Efficiency Due to Reheating in Steam Turbines," W. E. Blowney and G. B. Warren, Trans. A.S.M.E., vol. 46 (1924).

[7] This analysis was furnished by the engineers of Allis-Chalmers Mfg. Co., Milwaukee, Wis., U. S. A.

a reheat cycle the steam, after being partially expanded, is withdrawn and has heat added to it, after which it is returned to the unit and the expansion continued to exhaust pressure. If the additional energy that is rendered available by the reheating process is divided by the heat that is added to the steam in the reheater, the quotient expresses the efficiency at which the reheat is rendered available. Also, if the additional work that is done by a turbine, as a result of reheating, is divided by the heat added in the reheater, the quotient expresses the efficiency at which reheat is used.

Figs. 8, 9, and 10 summarize the results of calculations on the efficiency at which reheat is used with absolute steam pressures of 600 lb., 1200 lb., and 2000 lb. per sq. in. with 800 deg. fahr. and

The increase in thermal efficiency by the use of reheat seems to be due largely to the fact that the heat added by the reheater is utilized at a greater efficiency than that added by the boiler. At high reheat pressure ratios, the efficiency of the use of reheat is high, but the reheat added by the reheater is small, and at low reheat pressures the reverse is true. Inasmuch as the thermal efficiency of a reheat cycle is a combination of the amount of reheat and the efficiency of its utilization, there will be a certain reheat pressure for given operating conditions which shows highest thermal efficiency. Such reheat pressures are indicated by the points of maximum thermal efficiency on the curves of Figs. 8, 9, and 10. These maximum thermal efficiencies with extracting and reheating occur with reheat pressure ratios of 30 per cent

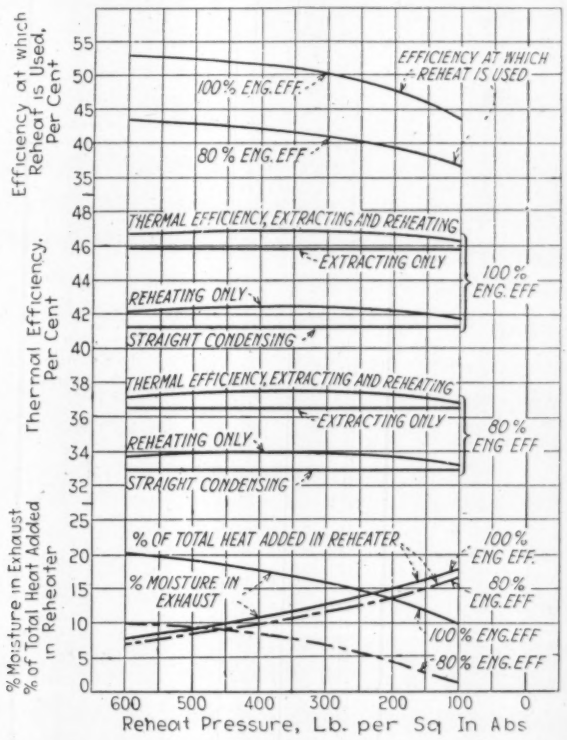
Efficiency at which Reheat is Used, Per Cent
Thermal Efficiency, Per Cent
% Moisture in Exhaust % of Total Heat Added in Reheater
EFFICIENCY AT WHICH REHEAT IS USED
100% ENG. EFF.
80% ENG. EFF.
THERMAL EFFICIENCY, EXTRACTING AND REHEATING
EXTRACTING ONLY
REHEATING ONLY
STRAIGHT CONDENSING
100% ENG. EFF
80% ENG EFF
% OF TOTAL HEAT ADDED IN REHEATER
% MOISTURE IN EXHAUST
100% ENG. EFF.
80% ENG. EFF
100% ENG. EFF
80% ENG. EFF
Reheat Pressure, Lb. per Sq In Abs

FIG. 9 AN ANALYSIS OF REHEATING WITH INITIAL CONDITIONS AT THE THROTTLE VALVE OF 1200 LB. PER SQ. IN. ABS., 800 DEG. FAHR., AND REHEATING AT VARIOUS PRESSURES TO 800 DEG. FAHR. WITH FINAL EXPANSION TO 29 IN. VACUUM FOR AN IDEAL TURBINE OF 100 PER CENT ENGINE EFFICIENCY AT THE COUPLING AND FOR ONE WITH 80 PER CENT ENGINE EFFICIENCY

(No allowance made for reheat factors, moisture correction, or pressure drop through reheater. See Fig. 8 for definitions of efficiency, etc.)

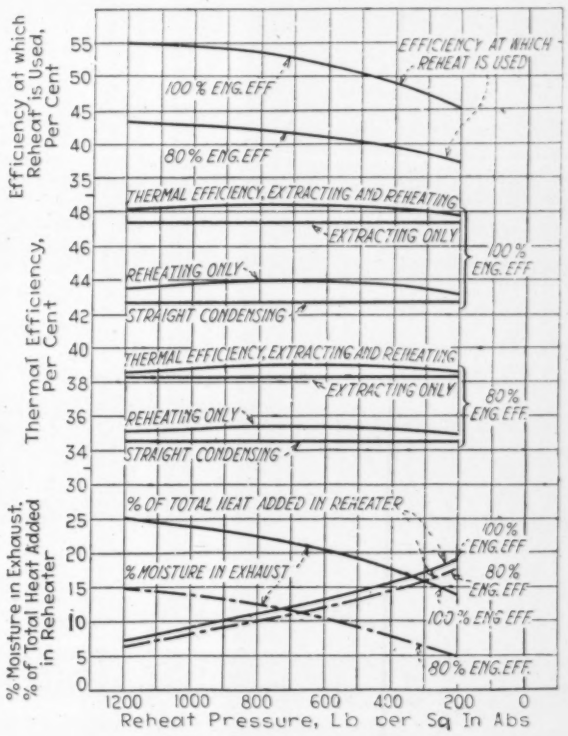
Efficiency at which Reheat is Used, Per Cent
Thermal Efficiency, Per Cent
% Moisture in Exhaust, % of Total Heat Added in Reheater
EFFICIENCY AT WHICH REHEAT IS USED
100% ENG. EFF
80% ENG. EFF
THERMAL EFFICIENCY, EXTRACTING AND REHEATING
EXTRACTING ONLY
REHEATING ONLY
STRAIGHT CONDENSING
100% ENG. EFF.
80% ENG. EFF.
% OF TOTAL HEAT ADDED IN REHEATER
% MOISTURE IN EXHAUST
100% ENG. EFF
80% ENG. EFF
100% ENG. EFF
80% ENG. EFF.
Reheat Pressure, Lb per Sq In Abs

FIG. 10 AN ANALYSIS OF REHEATING WITH INITIAL CONDITIONS OF 2000 LB. PER SQ. IN. ABS., 800 DEG. FAHR., AND REHEATING AT VARIOUS PRESSURES TO 800 DEG. FAHR. WITH FINAL EXPANSION TO 29 IN. VACUUM FOR AN IDEAL TURBINE OF 100 PER CENT ENGINE EFFICIENCY AT THE COUPLING AND FOR ONE WITH 80 PER CENT ENGINE EFFICIENCY

(No allowance made for reheat factors, moisture correction, or pressure drop through reheater. See Fig. 8 for definitions of efficiencies, etc.)

29 in. vacuum for different reheat pressures, with reheating in every case to the original temperature of 800 deg. fahr. and for engine efficiencies at the coupling of 100 per cent and 80 per cent, but with no regenerative bleeding. To simplify the problem, no allowance was made for reheat factors in these calculations, for moisture correction, or for pressure drop through reheaters. Computations were made for a non-reheat and a reheat turbine operating with exactly the same overall efficiency for each expansion in order to demonstrate the fundamental reheat efficiency and the actual gain in cycle efficiency irrespective of the influence of changes in moisture content on the efficiency of low-pressure turbine stages. The upper curves of Figs. 8 to 10, indicating the efficiency at which reheat is used, show increasing efficiency with the higher reheat pressure ratios. If allowance had been made for moisture in the low-pressure sections, the efficiency at which reheat is used at 80 per cent engine efficiency would have been increased over the values in the curves.

of the initial pressure at 80 per cent engine efficiency, which is somewhat higher than current practice of 20 to 25 per cent.

It would appear from experience as well as from theoretical considerations that blade erosion of an objectionable amount is as much a function of blade speed as of the percentage of moisture. There is evidence to support this conclusion in the high efficiencies that were obtained on large machines at earlier dates, when the amount of superheat as well as the steam pressure was less than now but lower blade speeds and steam speeds were used. The loss due to moisture on these turbines could not have been as great as with the high blade speeds now prevailing. The economy of reheat applications would therefore appear to be closely associated not only with increases in steam pressure and the effort to secure lower heat consumption, but also with the increase in size of units and the accompanying higher blade and steam speeds in the low-pressure stages.

A study of Figs. 8 to 10 indicates that the efficiency at which

the reheat is used is substantially constant at the various reheat pressure ratios with 80 per cent engine efficiency, within the limits of a Mollier diagram, in all three cases. Calculations show that the B.t.u. gain in available heat at 80 per cent engine efficiency and with reheat to 800 deg. fahr. at all usual reheat ratios, increases with the higher pressures. Hence the total gain in work from the reheat must also increase with the higher pressures. This is shown by the thermal-efficiency curves of Figs. 8 to 10 with extracting and reheating at 80 per cent engine efficiency, where the thermal efficiencies at a reheat pressure ratio of 30 per cent increase from 36 per cent at 600 lb. abs. to 37.5 per cent at 1200 lb. abs. and to 39 per cent at 2000 lb. per sq. in. abs. This suggests that the decrease in heat consumption with 2000 lb. may justify the use of that pressure in place of 1200 lb. as in present practice.

Table 2, taken from the study of a particular turbine, shows the gains that are realized when various extraction cycles are imposed on a reheat cycle. The data in this table differ from those used in the previous analysis, in that these results are based on a stage efficiency corrected for moisture in the exhaust. It will be seen that for the conditions given, the net gain due to reheat is 4.16 per cent with no extraction and 3.44 per cent with four extraction heaters. The decrease in gain is probably due to the decreased amount of heat from the reheater utilized in the case of the extracting cycle. These data indicate that with four-stage bleeding the effect of extraction is to make available only about 85 per cent of the net gain due to reheating on a straight condensing basis.

TABLE 2 EFFECT OF EXTRACTION ON THE GAINS OBTAINED BY REHEATING

Feedwater heated to different temperatures. Initial conditions: 550 lb. per sq. in. gage, 720 deg. fahr., 1362 B.t.u., reheat at 60 lb. per sq. in. abs., 500 deg. fahr. reheat temp., 29 in. vacuum.
Stage efficiency, 83 per cent with expansion line corrected for moisture at rate of 1 per cent correction for 1 per cent average moisture content.
Normal maximum rating, 100,000 kw. Most efficient load on unit, 60,000 kw.

No. of bleeder heaters	Final feed-water temp., deg. fahr.	Heat consumption in B.t.u. per kw-hr.		Per cent gain in heat consumption with reheat	Cycle efficiency	
		Standard condensing	With reheat		Standard condensing	With reheat
0	79	11,300	10,830	4.16	0.302	0.3155
1	142	10,900	10,470	3.95	0.313	0.3265
2	210	10,590	10,200	3.68	0.3225	0.3350
3	282	10,325	9,980	3.36	0.3310	0.3420
4	342	10,190	9,840	3.44	0.3350	0.3470

THE ECONOMIC SELECTION OF A LARGE STEAM TURBINE

Little attention is paid in America to engine efficiencies alone in selecting turbines for a given service, since these efficiencies are generally highest at only moderate vacuum. Engineers demand units that will give the best performance in B.t.u. per kilowatt-hour. This leads to particular care in the recovery of all waste heat through the use of generator air coolers, oil coolers, and inter- and after-condensers on steam-jet air pumps, and to the most economical arrangement of bleeders and evaporators. Condensers and condenser pumps are designed to secure the maximum vacuum with the temperature of the water at hand, and plant sites are chosen where large supplies of cold circulating water are available. It has been found economical at times to pump as much as 120 lb. of cooling water through the condensers per pound of steam condensed in order to secure best plant performance.

Attention has already been called to the low average use factors that prevail throughout the economic life of a turbine. These are not always given due weight, and higher efficiencies are sometimes demanded in turbines than are warranted by local operating conditions. Assume that two turbines of the same size are required for two plants, one with high use factors and high fuel cost, and the other a stand-by to a hydroelectric plant with low use factors and cheap fuel. In the first case a design for highest economy is needed for which a high price can be paid; in the second a cheap unit of indifferent efficiency will serve most economically. The price of "made-to-order" units for each such service would be unduly high. Manufacturers have developed certain standard sizes of casings, and these may be utilized to suit almost every demand at reasonable cost and efficiency.

A turbine casing can be given a number of ratings and can be provided with generators of varying capacity while keeping the annular area of the last row of blades constant, by changing the leaving velocity from the last row and adjusting the dimensions of the high-pressure blading to the quantity of steam flowing at the given rating. This casing can have low ratings with low leaving losses for operation with high use factors and high fuel costs, and high ratings with high leaving losses when use factors are low and fuel is cheap. The cost of a turbine for a given speed varies in general with the area of the last row of blades, for the high-pressure blading can usually be modified as desired with little change in total cost. Furthermore, when the casing is given high ratings the increased steam flow through the high-pressure blading results in longer blades with a lower percentage of leakage, and hence in high efficiency. This gain partly offsets the increased leaving losses at this high rating. Hence a low-use-factor turbine can be manufactured at low cost per kilowatt by increasing the rated output of a given casing.

The area of the annulus of the last row of blades per 1000 kw. and the leaving losses therefrom have varied during the past few years. In the early days of turbine construction, units were small and an ample blade annulus could be provided at little increased cost, but velocities in these areas became high as capacity of casings increased. Increased capacities and the construction of turbines with maximum rating well above the most efficient load, have resulted in progressively decreasing annular area per 1000 kw. of capacity at rating and in higher leaving velocities. The single annulus of low-pressure blades at 1800 r.p.m. has increased to over 80 sq. ft. At present the annulus of the last blade row varies from about 1.25 to 2.5 sq. ft. per 1000 kw. of turbine rating. The average values of the leaving losses vary from 1.5 to 5 per cent of the total adiabatic heat drop from initial steam conditions to vacuum.

Improvements in blade design have resulted in new forms of blade fastenings and in the use of warped and tapered blades for the longest rows, so that troubles from this source are less frequent than formerly. Blades have been increased in length to 34 in., and the mean diameters of the last rows have also increased so that maximum tip speeds of 1147 ft. per sec. are used on reaction turbines of American design at 1800 r.p.m.

The test data of the Nozzle Research Committee of the Institution of Mechanical Engineers indicate that convergent nozzles may operate at high efficiency with a greater pressure drop than the critical. The pressure drop across the last row of many reaction turbines operating at high rating may exceed the critical value. Possibly the increase of rating of the last row of blading without greater loss in overall efficiency may be due, as indicated by the above tests, to a better nozzle efficiency of these rows than has formerly been assumed.

Areas of exhaust openings to the condenser vary from 2.5 to 5 sq. ft. per 1000 kw. of rated capacity. The usual allowance appears to be about 4 sq. ft. per 1000 kw. When high leaving velocities are used, such large exhaust pipes need not be furnished as the steam in its short passage to the condenser seldom utilizes the full area of the pipe, and smaller ratios of exhaust area are permissible if the condenser design provides for proper steam distribution.

(To be concluded)

The Application of Tungsten Carbide to Circular Saws

Changes That Have Recently Taken Place in the Design of Saws—Results Obtained With Saws Provided With Tungsten-Carbide-Tipped Teeth in Cutting a Variety of Materials

By C. M. THOMPSON,[1] PHILADELPHIA, PA.

IT IS THE PURPOSE of this paper to outline briefly the changes that have taken place in the design of circular saws, and to state some of the remarkable results recently achieved through the use of tungsten carbide tips brazed to the teeth at the cutting edge.

The circular saw was first introduced about 150 years ago, has passed through three stages of development, and is now in the fourth. These development periods may be stated as follows:

(1) 1777 to 1840—Solid Saws
(2) 1840 to 1905—Carbon-Steel Inserted-Tooth Saws
(3) 1905 to 1929—High-Speed-Steel Inserted-Tooth Saws
(4) 1929—Tungsten-Carbide-Tipped Inserted-Tooth Saws.

The brazing of tungsten carbide to steel requires a temperature between 2100 and 2200 deg. fahr., which offers extreme difficulties in the case of solid saws, especially those of thin-gage metal and with diameters greater than six inches. The inserted-tooth saw, on the other hand, lends itself readily to the application of tungsten carbide.

Naturally many improvements followed the early designs of inserted-tooth saws, but it was not until the introduction of high-speed steel that greater speeds and feeds became possible.

The introduction of tungsten carbide in the past year has been the beginning of a new era in the art of saw making which promises to be revolutionary. Saws tipped with this hard material will operate at speeds and feeds far beyond the range of high-speed steel without losing their cutting edges or clearances, and will produce from ten to fifty times the work per sharpening, depending upon the material being cut.

As with shop tools, it has been necessary to discard largely our former theories and practice and start anew to design teeth which will sufficiently support the tungsten carbide tip and withstand the shocks to which it will be subjected. When it is realized that a saw tooth is a cutting tool which is always subjected to intermittent duty, and that not only is the saw in motion as well as the work but the line of contact of the cutting tool with the work is constantly changing, it will be apparent that the problem of design is different from that of the general run of shop tools. To design a saw tooth properly it is necessary to know the position of the saw with relation to the work, the speed, and the rate of feed.

Forces Acting on a Saw Tooth

The forces acting upon a saw tooth compared to those acting upon lathe and planer tools are shown in Fig. 1. It will be noted that the forces acting upon a saw tooth are in a plane perpendicular to the axis of the blade, while in the case of lathe and planer

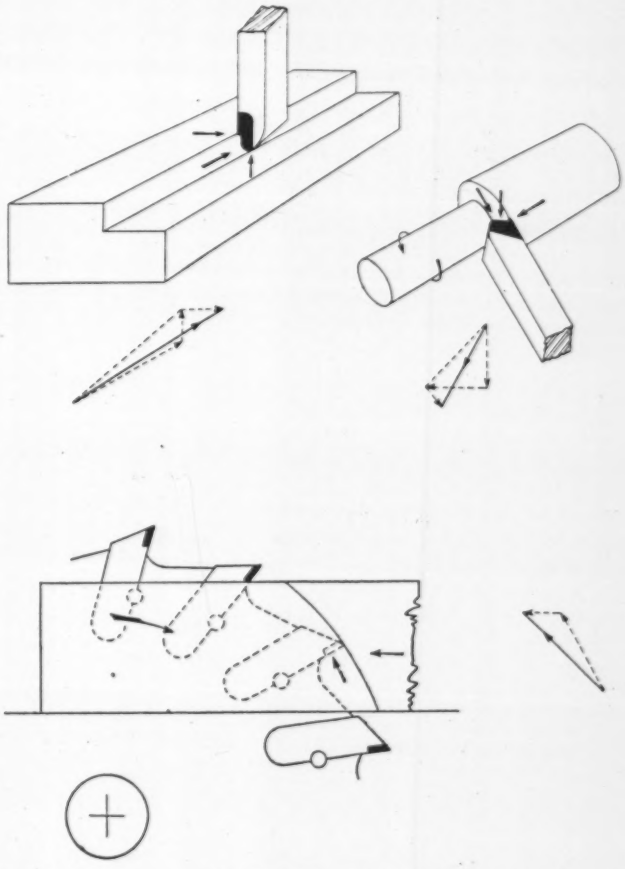

Fig. 1 Diagrams of Forces Acting on a Lathe Tool, a Planer Tool, and a Saw Tooth

tools the forces are not all in the same plane and the resultant therefore acts obliquely. While the load per tooth is relatively small, the design must be such that abrasion resulting from the high speed employed will not affect the ferrous body.

The first public demonstration of a saw tipped with tungsten carbide was in Cleveland last October at the Machine Tool Builders' Exhibition. This was a 16-in.-diameter saw with 60 teeth running at 2400 r.p.m. on a cut-off machine equipped with a 25-hp. motor. Three-inch-round brass stock was severed in three seconds. Before being shipped to Cleveland this saw was oper-

[1] Products Engineer, Henry Disston & Sons, Inc. Mr. Thompson has been connected with this company since 1924; prior to August, 1929, when he took charge of the developments and production of carboloy-tipped saws, he served in the capacity of plant engineer.

Contributed by the Machine Shop Practice Division and presented at the Semi-Annual Meeting, Detroit, Mich., June 9–12, 1930, of The American Society of Mechan.cal Engineers.

ated in the Disston experimental department on the same machine but with a 10-hp. motor, which was standard equipment at that time. At the same speed and feed the power input was 27 hp., and when the feed was increased slightly the motor was stalled. From the information obtained by the operation of this saw it was believed possible to design a saw which would operate satisfactorily on this class of work at speeds in excess of 15,000 ft. per min. These expectations have been realized.

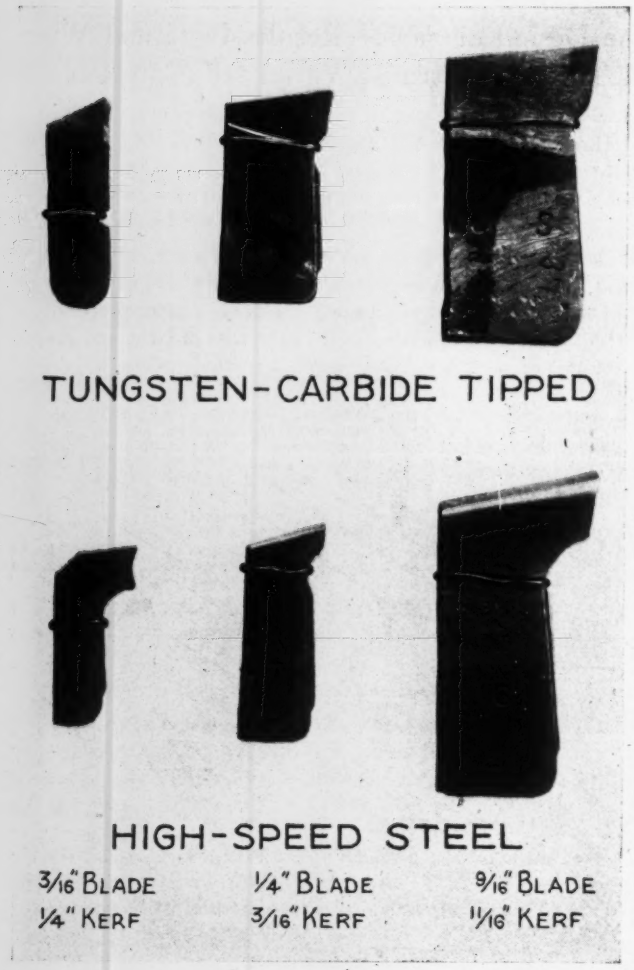

FIG. 2 SHOWING THREE SIZES EACH OF TUNGSTEN-CARBIDE-TIPPED AND HIGH-SPEED-STEEL SAW TEETH

Fig. 2 shows three sizes of tungsten-carbide-tipped teeth, together with the corresponding high-speed-steel teeth. The increased thickness and blunter nose of the tipped teeth are to be noted.

RESULTS OBTAINED IN CUTTING VARIOUS MATERIALS

Prior to the Cleveland demonstration of non-ferrous-metal cutting, saws tipped with tungsten carbide were producing remarkable results on wood substitutes and on the low-tensile abrasives. In one particular case where high-speed-steel saws cut, on the average, 250 ft. of a very abrasive wall board, the tungsten-carbide-tipped saw cut over 3000 ft. The result in this plant has been the replacing of three stripping machines with one higher-speed machine equipped with these saws for the same production. In the sawing of slate one machine equipped with a tungsten-carbide-tipped saw supplied material for a battery of planers which formerly required three machines. Another application has been in an asbestos-pipe-covering industry where the steel saw cut 2000 sections per sharpening compared to 90,800 sections with the tungsten-carbide-tipped saw.

Probably one of the most spectacular demonstrations was that at the League Island Navy Yard in Philadelphia where 16-in. heat-treated armor plate was sawed.[2]

Tests have been conducted on the cutting of wood which have brought to light very interesting results. In one case a tungsten-carbide-tipped saw was put in production on a power-feed rip machine cutting $1^5/_8$-in. hard maple where the steel saws previously used had to be changed for sharpening every other day. After four weeks of operation, during which time 28,000 lineal feet of material had been cut, the saw was removed for examination. A slight rounding of the cutting edges was apparent, and after very careful measurements the teeth were lapped to keen edges and further measurements disclosed the fact that resharpening had only reduced the diameter of the saw 0.005 in. Another test of a 14-in.-diameter saw was conducted at the plant of a prominent woodworking-machine company on a power rip machine of recent design, operating at 7200 r.p.m. (26,400 ft. rim speed) and with a feed of 300 ft. per min. This test was discontinued after cutting 1500 ft. owing to the inability of the machine to withstand the speed and lack of handling equipment for this feed.

Table 1 summarizes the results obtained in two widely different metal-cutting production operations.

Since it is not possible to make an inserted-tooth saw of a given diameter with the same number of teeth as in a solid blade, it is necessary to increase the speed where a very clean cut is desired. This is one of the problems facing the manufacturer of tungsten-carbide-tipped saws, for in very few instances are the machines now used suitable for the higher speeds called for. It is to be hoped that the saw-machine manufacturers will follow in the footsteps of the machine-tool manufacturers with designs that will permit the use of tungsten-carbide-tipped saws efficiently and economically. Machines on which this type of circular saw is operated must be free from vibration, and the arbors and collars must be true if the best results are to be obtained.

TABLE 1 SUMMARY OF RESULTS OBTAINED IN TWO DIFFERENT METAL-CUTTING OPERATIONS

Metal cut	Armor plate		Copper-tin alloy	
Inserted teeth used	Carboloy tipped	High-speed	Carboloy tipped	High-speed
Diameter of saw, inches	48	48½	10	10
Number of teeth	48	72	36	36
Thickness of plate, inches	9/16	5/8	1/4	1/4
Width of kerf, inches	11/16	3/4	5/16	5/16
Total length of cut, inches	98½	73	2994	2994
Maximum speed, r.p.m.	3	2	620	450
Maximum feed, inches per minute	0.285	0.180	6	2
Average rate cut in feet per hour	0.682	0.435	186	36.5
Number of saw sets	1	1	3	32
Saw-changing time in hours	...	...	0	29

Tungsten-carbide-tipped saws should not be allowed to dull to the extent of having to waste the expensive material by grinding it away, but should be sharpened by lapping as soon as slight dulling of the cutting edges is noticeable. Sharpening equipment in these indicate production increases that will have considerable significance as regards our economic structure.

There are other saw applications, such as drag saws, with which remarkable results have been obtained in the limestone industry, and although this paper has covered only a few of the many circular-saw applications, the results which are being obtained in these indicate production increases that will have considerable significance as regards our economic structure.

[2] A complete description of this saw and its performance appeared in an article by H. B. Allen in the *Carboloy Magazine*, vol. 2, nos. 2 and 3, 1930.

The Use of Tungsten Carbide as a Cutting Material on Heavy Machine Tools

By COLEMAN SELLERS, 3RD,[1] PHILADELPHIA, PA.

A brief review of the experience of an early user of tungsten carbide tools on cast iron, in which the author describes the steps taken to introduce this material into the machine shop and the method used to follow up the results obtained. The grinding problem is discussed and the importance of grinding correctly is stressed. A few suggestions are given for grinding procedure, clearance angles, and shapes of tools. The types of tools used are described and commented upon. Next the difficulties are listed, with possible remedies for each, and, in contrast, six typical successful applications are described. In conclusion, the advantages and disadvantages are briefly set forth.

SINCE the introduction of cutting tools tipped with cemented tungsten carbide in the latter part of 1928, Wm. Sellers & Co., Inc., have been interested in the possibilities of this new cutting material.

All in all, their experience shows that there are great possibilities in the value of tungsten carbide in the art of cutting metals, but there are many limitations which must be thoroughly understood by the users for its successful application. In addition, there are defects and weaknesses in this highly expensive material which must be overcome by its manufacturers.

For the benefit of those who are contemplating the use or who are actually introducing tungsten carbide into their shops, the author proposes to recount a number of actual experiences, including those of successful as well as unsuccessful applications. While it is realized that tungsten carbide is used in cutting many kinds of material, including certain types of steel, only cast iron will be considered in this paper, as the major part of the work of the company with which he is connected has been with this metal.

Before proceeding further it will be well to give a brief description of the Sellers shop. The company does not have a regular production. Only two or three small machines are manufactured in quantities of 25, the majority of the work being in lots of from 2 to 12 and the larger pieces—up to 80,000 lb. weight—being built singly or in pairs. It is therefore impossible to make comparisons by running several days on one operation with one cutting material, and then several days with another on the same operation. All machine work is paid for on a piece-work basis, with the price established in advance. This necessitated the rate setter's working with the machine hand on introducing tungsten carbide, as the possibilities of this material were not definitely known. The machine-tool equipment is in good condition and includes turret lathes of all sizes, engine lathes of 12 to 48 in. swing, planers from 36 to 120 in. between housings, horizontal boring mills with spindles up to 6 in., and vertical boring and turning mills of from 42 in. to 16 ft. swing.

When the first tungsten carbide tools were purchased and placed in the shop, one man—a member of the shop supervisory force—was assigned to follow them up along with his other work. He was directed to work with the manufacturer's application men in recommending jobs on which this cutting material should be used, and where it failed, to determine the cause. If the fault lay in the set-up or was due to the machine operator, he corrected the difficulty. If the fault lay elsewhere, he worked with the manufacturer's representative for the proper solution.

The point has now been reached where these tools are carried in the toolroom, with the exception of a few special experimental tools. Any man may obtain these tools on check provided he has a written memorandum from his foreman. This limitation is placed on their use to prevent unprofitable applications. The foremen are sufficiently familiar with the material to be able to authorize its employment where desirable. It may be to save from the scrap pile some unusually hard castings, or it may be on a new job which has never before been considered as a possibility. In this case the tungsten carbide "expert" must be notified so that he may follow up the job and have the rate department adjust the piece-work price accordingly. In addition, for certain operations the operation sheets specify the use of tungsten carbide, and the piece-work price is figured on this basis.

Instructions Issued to Shop

The foremen are provided with a supply of blueprints prepared by the Engineering Department and covering a few of the precautions to be observed by the operator. These read as follows:

Instructions for Use of Tungsten Carbide Tools

These tools are expensive and must be handled with care.

The tips are extremely brittle and may chip or crack if hit with a hammer or dropped on a hard surface.

These tools must have a keen cutting edge, and the clearance angles and rakes are not the same as with high-speed steel. Do not attempt to alter or have special shapes ground.

Do not use these tools where there is excessive chatter or vibration.

Always support the tool with the least possible overhang from the tool apron or tool post. Excessive overhang is one of the principal causes of chatter and consequent failure of the tungsten carbide tools.

Be sure that the work is held securely on the machine.

Do not stop the machine while the tool is in the cut—it is likely to pull the tip off of the shank. Let the feed run out before stopping the machine for measuring.

Many of these tools are on trial, and we must have data on the results obtained with them. On every job we use tungsten carbide

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[1] Executive Engineer, William Sellers & Co., Inc. Mem. A.S.M.E. Mr. Sellers was graduated from the University of Pennsylvania, Mechanical Engineering Department, in 1915, and entered the shops of Wm. Sellers & Co., Inc., immediately thereafter. He worked in various parts of the shop and finally became foreman of a fitter gang. After two years he became associated with the Midvale Steel Company, in charge of repairs to machine tools in all eight machine shops. January 1, 1919, he returned to Wm. Sellers & Co. as assistant superintendent, and as been there since, his present position being executive engineer in charge of the engineering and production departments.

Contributed by the Machine Shop Practice Division and presented at the Semi-Annual Meeting, Detroit, Mich., June 9 to 12, 1930, of The American Society of Mechanical Engineers. All papers are subject to revision.

CUTTING TOOL RECORD

WM. SELLERS & CO., INC.

TO BE FILLED IN BY FOREMAN OR RATE SETTER

Tool Serial No. _____ Cutting Tool Name or Symbol _____

Material Cut _____ Machine on which Tool is used _____

Cutting Speeds	Feeds	Depth of Cut	Condition of Tool After Cut

Time Tool was in Use _____ Cubic Inches of Metal Removed _____

Order No. _____ Pc. No. _____ No. of Pcs. _____

Name of Piece _____

Remarks _____

TO BE FILLED IN BY OFFICE

Mfgr. _____ Shape or Style _____

Size of Shank _____ Size of Tip and Method of Holding _____

FIG. 1 RECORD CARD TO BE FILLED OUT FOR EACH JOB USING TUNGSTEN CARBIDE TOOLS

tools, a report must be turned in by your foreman or by the rate setter. Be sure that this card is filled out and returned to the office promptly.

WM. SELLERS & CO., INC.

Each man is given one of these instruction sheets when he first starts to use tungsten carbide tools. In addition, with each job assigned where these tools are used, a record card like that shown in Fig. 1 must be filled out by the foreman or rate setter and sent to the Engineering Department through the superintendent. This practice is intended to be in force only during the development of the shop practice for this material, and while the tools are still more or less in the experimental stage. Every tungsten carbide tool entering the plant is given a serial number. This is recorded in the office with a description of the tool, the date purchased, order number, etc. The report cards turned in furnish a comprehensive record of the performance of the tool, and all those that do not prove profitable can then be investigated.

GRINDING TUNGSTEN CARBIDE TOOLS

One of the most important points in the successful application of tungsten carbide tools is the grinding of the cutting edge. This subject has been thoroughly investigated by a member of the company's engineering staff. It has been found, first of all, that a keen edge, free from nicks and lumps, is essential for all but the heaviest roughing operations. Even in the latter types of cuts, a much sharper tool is desirable than that required on high-speed steel. By a keen cutting edge is meant one that is sharp and does not show irregularities, even under a magnifying glass.

The clearance angles should be somewhat less than those adopted as good practice on high-speed steel. This is due to the inherent lack of strength of tungsten carbide and the consequent necessity of supporting the cutting edge as rigidly as possible. With some types of brazing, especially where the tools are to be subjected to heavy cutting pressures, it is desirable to grind with a slight negative back slope on the top of the tool. This tends to hold the tip in place and eliminates the tendency to pull it away from the shank.

The company has entirely eliminated hand grinding. In the first place, it is not desired that the machine-tool operator shall grind his own tools, as in that case it would never be possible to control the quality of the grinding or insure the use of the correct rakes or clearance angles. All dulled tools are turned into the toolroom, where they are machine ground by a reliable and experienced operator. Hand grinding not only tends to produce mediocre results, but it is a slow and expensive operation. Actual tests have shown that grinding by hand, or "off-hand grinding" as it is sometimes called, takes from three to four times as long as on the machine to produce an equally good cutting edge. This is partly accounted for by the fact that with hand grinding it is necessary to rough on a 60-grit wheel and finish on a 100- or 120-grit wheel, whereas with the machine it is only necessary to employ one wheel of 60 or 80 grit. Another advantage of the machine is that it permits the use of water, which speeds up the operation. Hand grinding cannot be done wet with any degree of satisfaction, as the quantity of water required would obscure the tool from the eyes of the operator, besides necessitating the continual wetting of his hands, producing unpleasant and, in cold weather, almost impossible working conditions. A little water is worse than none, as it will tend to injure the tungsten carbide by alternate heating and cooling. If water is used it must be in abundant

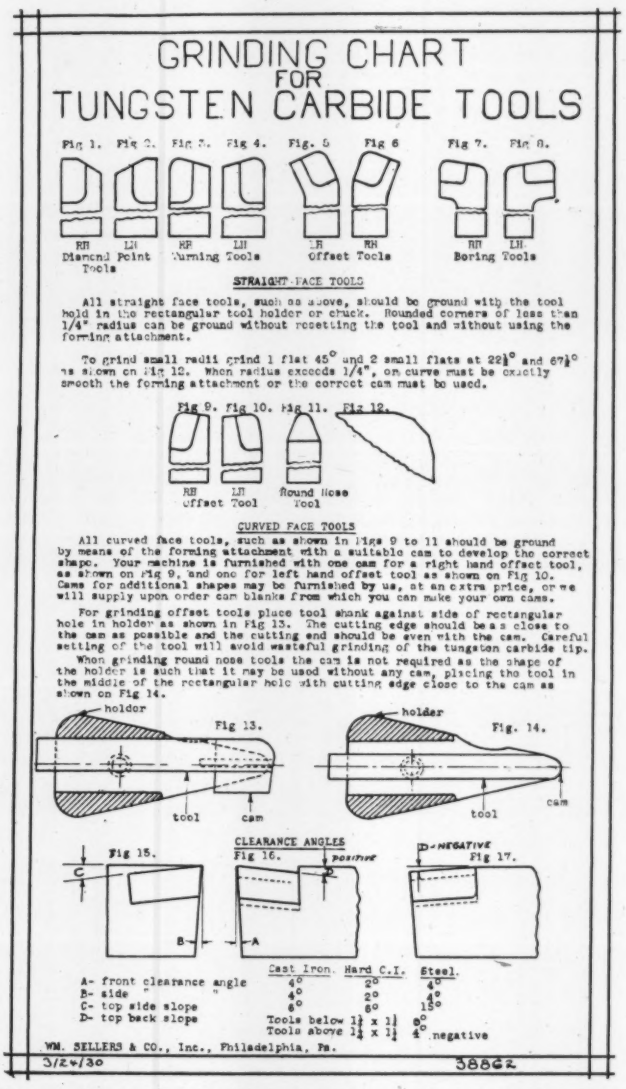
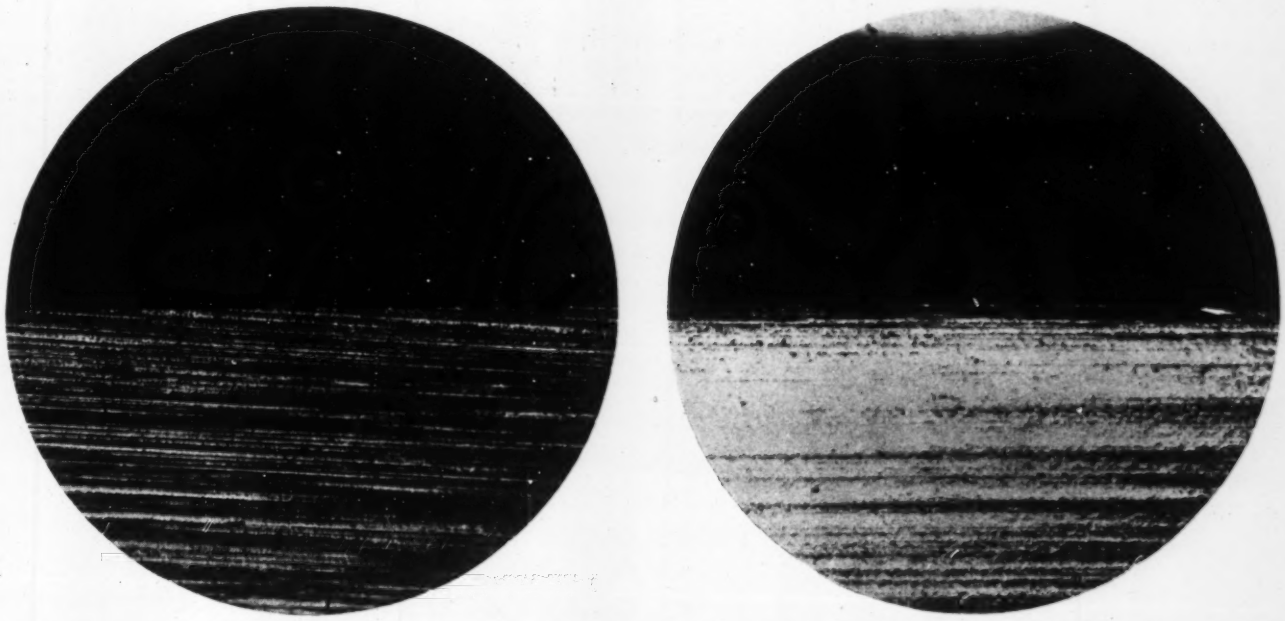
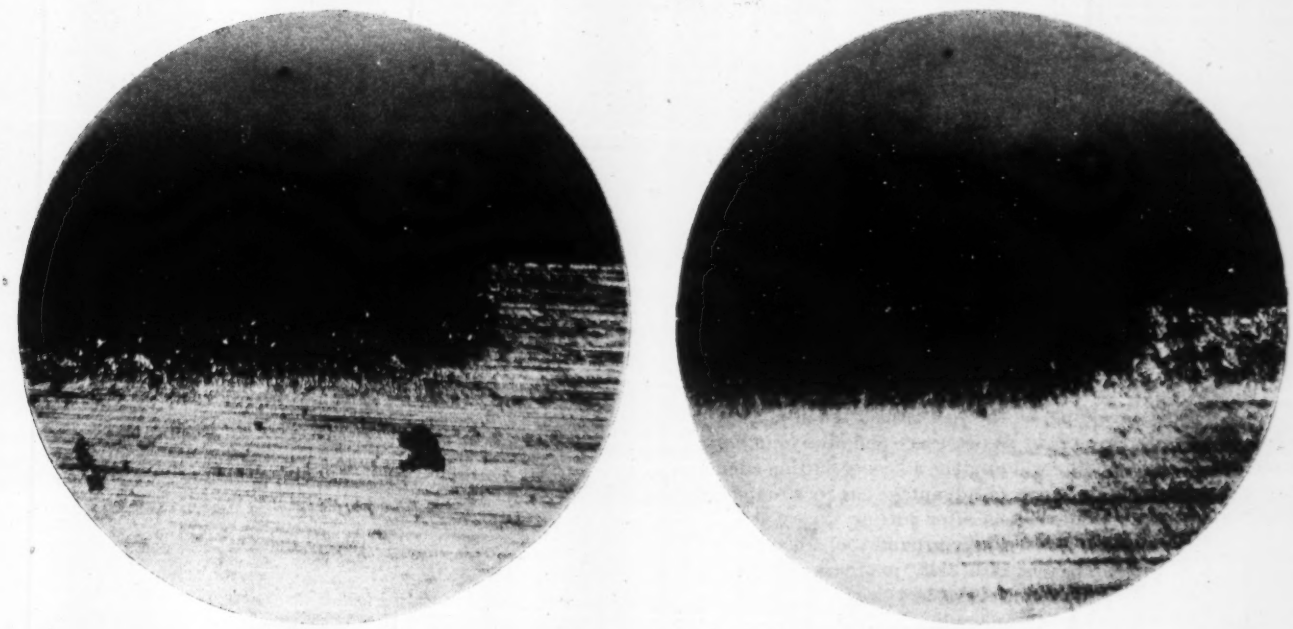

GRINDING CHART
FOR
TUNGSTEN CARBIDE TOOLS
Fig 1. Fig 2. Fig 3. Fig 4. Fig. 5 Fig 6 Fig 7. Fig 8.
RH LH RH LH LH RH RH LH
Diamond Point Tools
Turning Tools
Offset Tools
Boring Tools
STRAIGHT FACE TOOLS
All straight face tools, such as above, should be ground with the tool held in the rectangular tool holder or chuck. Rounded corners of less than 1/4" radius can be ground without resetting the tool and without using the forming attachment.
To grind small radii grind 1 flat 45° and 2 small flats at 22½° and 67½° as shown on Fig 12. When radius exceeds 1/4", on curve must be exactly smooth the forming attachment or the correct cam must be used.
Fig 9. Fig 10. Fig 11. Fig 12.
RH Offset Tool
LH Offset Tool
Round Nose Tool
CURVED FACE TOOLS
All curved face tools, such as shown in Figs 9 to 11 should be ground by means of the forming attachment with a suitable cam to develop the correct shape. Your machine is furnished with one cam for a right hand offset tool, as shown on Fig 9, and one for left hand offset tool as shown on Fig 10. Cams for additional shapes may be furnished by us, at an extra price, or we will supply upon order cam blanks from which you can make your own cams.
For grinding offset tools place tool shank against side of rectangular hole in holder as shown in Fig 13. The cutting edge should be as close to the cam as possible and the cutting end should be even with the cam. Careful setting of the tool will avoid wasteful grinding of the tungsten carbide tip.
When grinding round nose tools the cam is not required as the shape of the holder is such that it may be used without any cam, placing the tool in the middle of the rectangular hole with cutting edge close to the cam as shown on Fig 14.
holder
Fig 13.
tool
cam
holder
Fig. 14.
tool
cam
CLEARANCE ANGLES
Fig 15.
Fig 16.
POSITIVE
D-NEGATIVE
Fig 17.
C
B
A
D
Cast Iron. Hard C.I. Steel.
A- front clearance angle 4° 20 4°
B- side " " 4° 20 4°
C- top side slope 6° 60 12°
D- top back slope Tools below 1¼ x 1¼ 6°
Tools above 1¼ x 1¼ 4° negative
WM. SELLERS & CO., Inc., Philadelphia, Pa.
3/24/30
38862

FIG. 2 CHART GIVING INSTRUCTIONS FOR GRINDING TUNGSTEN CARBIDE TOOLS



(*a*) Ground and lapped. (*b*) Ground only.

FIG. 3 CUTTING EDGES OF FINISHING TOOLS. × 38



(*a*) Ground and lapped. (*b*) Ground only.

FIG. 4 TOOLS SHOWN IN FIG. 4 AFTER CUTTING 3 STROKES ON PLANER

quantity, at low velocity, and directed to the part of the tool in contact with the wheel. A further advantage resulting from the use of water is the elimination of the abrasive dust, which in heavy cutting is serious on account of the excessive wear of the soft wheels required to grind tungsten carbide.

The machines used in the preliminary tests and later in regular shop practice were two tool grinders, one of them for tools over $1^1/_2 \times 2$ in. in section. Grinding times vary from 35 min. when shaping out from a very rough tip placed on a $1^1/_2 \times 2$-in. shank, to 3 min. for touching up two surfaces of a tool.

The shapes used are various. So far the recommendations of the manufacturers have been largely accepted as they have been found satisfactory, although not necessarily the most efficient. These are shown in Fig. 2, the chart which was prepared as instructions for operating the smaller tool grinder. The offset tools shown in Figs. 9 and 10 of this chart are good all-around roughing tools. The curved cutting edge has an advantage for tungsten carbide as it eliminates some of the shock on entering or leaving a cut.

The procedure in grinding tungsten carbide is different from that followed for steel. In the first place, a different wheel must be used. The abrasive employed is silicon carbide with a soft bond, as other abrasives are no harder than the tungsten carbide and will be cut away as if they were being dressed with a diamond.

Only light pressure must be applied. Heavy pressure will not only tend to injure the tool but will rapidly wear away the wheel and will not cut the material as fast. A good operator soon gets the "feel," and will not attempt to "hog" the tungsten carbide off.

Under no conditions when grinding dry should a tool when heated from grinding be dipped into water.

The clearance angles and rakes should be less than for steel

FIG. 5 TYPICAL GENERAL-PURPOSE TOOL

in order to give support to the cutting edge. It is therefore necessary to maintain the angles accurately.

It is claimed that in hand grinding the tool must be held so that the surface of the wheel advances toward the cutting edge. This is to prevent the wheel from chipping the edge as it leaves the surface of the tool. The author has not found this to be the case in machine grinding, as the tool is held much more steady and the cut may be as light as necessary and always uniform.

Lapping after grinding will produce a keener cutting edge. In machining cast iron, however, no advantage has been found in this extra operation. A lapped tool after cutting a very short time has no better edge than a carefully ground tool unlapped, even in finishing cuts. To illustrate this, photomicrographs were taken of two tools. Fig. 3(*a*) shows the ground and lapped tool and Fig. 3(*b*) the tool that was only ground. This was before they had cut. Fig. 4 shows the same two tools after three strokes 3 ft. long on a planer, 50 ft. per min., 0.005 in. depth of cut and $^1/_2$ in. feed, on close-grained medium iron.

At the present time the company is using tungsten carbide tools on cast iron in engine lathes, turret lathes, vertical boring and turning mills of all sizes, planers large and small, and horizontal boring machines. Too much emphasis cannot be placed on the rigidity with which both the tool and the work should be held. The shank must be of sufficient size for the pressure produced by the cut to be taken. The tool must be supported as close to the cutting edge as possible. The machine tool should not have lost motion in the tool post or tool apron, and the work must not spring. If these conditions do not obtain, chatter will result—and chatter is the worst enemy of tungsten carbide.

Many are under the impression that intermittent cuts are impractical. This has not been found to be the case, and such cuts are being run every day. There is no particular difficulty in using these tools on planing machines but tool lifters should be employed so that the tool will not drag over the work on the return cut, with the danger of loosening the tip.

VARIOUS FORMS OF TOOLS USED

Various forms of tipped tools are being used by the company. All are brazed to the shank, but some are also held by other means as brazing by itself is not always sufficient to resist high pressure.

Perhaps the commonest tool is that shown in Fig. 5. The tip is set into the shank so that it is supported firmly on the bottom and backed up on one side and the rear. The tool is successful in moderate cuts. Many of these tools, especially the earlier ones, failed through incorrect brazing, and the tips were loosened or broken off.

The bridge tool, Fig. 6, holds the tungsten carbide tip securely, and the company has never had one loosen. However, the projection or bridge on the top of the tool makes it difficult to grind and interferes seriously with the chips on heavy cuts.

The dovetail tool shown in Fig. 7 seems to be the most satis-

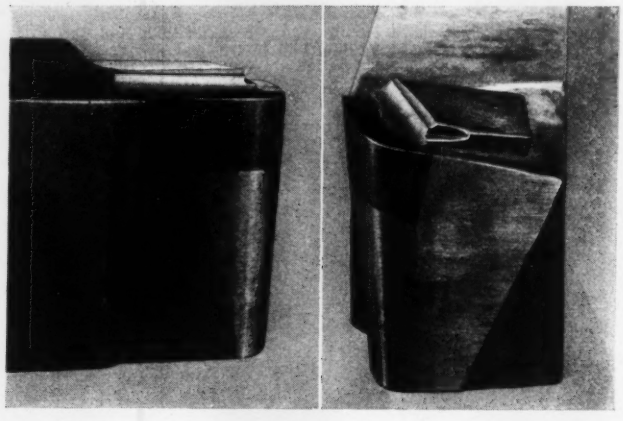


FIG. 6 BRIDGE TOOL FOR HEAVY ROUGHING

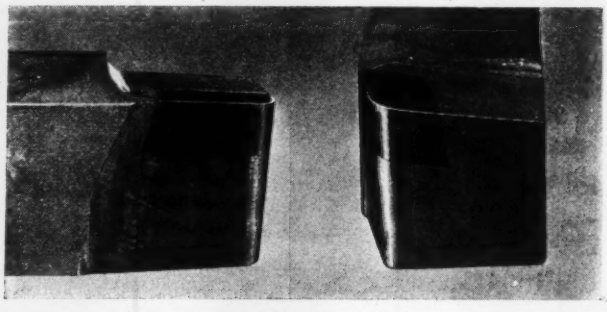


FIG. 7 DOVETAIL TOOL FOR HEAVY ROUGHING

factory of all, as the tip is readily accessible for any required depth of cut and for grinding. The wedging action of the dovetail helps to hold it securely against the heaviest pressures.

The type of tool shown in Fig. 8 holds the tungsten carbide tip very satisfactorily, but unless the shank is ground away the depth of the cut is too limited, and only light cuts may be taken.

Finishing tools of the type shown in Fig. 9 have proved very satisfactory.

FAILURES LISTED

The failures of tungsten carbide tools may roughly be charged

to (1) tip loosening, (2) to soft tungsten carbide, and (3) to tip breaking or chipping.

The loosening of the tips seems to have been caused by:

a Improper brazing. This appears to have been largely corrected by the manufacturers.

b Improper backing. The shanks did not have sufficient metal at the sides of the tip to prevent slight movement sideways, loosening the tip. The remedy is heavier shanks.

c Dragging the tool back over the work on heavy planing. The tool gets very hot on the cut, and then is dragged on the return stroke. This sometimes breaks or loosens tips. The remedy is a tool lifter on the planer.

The tips are broken or chipped by:

a Too light a shank. This will allow the shank to bend and thus remove the support under the tip, which of course will crack. The remedy is obvious.

b Too much copper in the braze. This was particularly true in some of the first year's tools. The copper was 0.010 in. to 0.015 in. thick. The pressure of the cut squeezed the copper out from under the tip where the cut was applied. This left a space between the tip and shank, and the tip eventually broke. The broken tools showed practically no copper under the front end of the tip, while the back end apparently had an excellent braze. The remedy lies in securing closer contact between tips and shank, allowing only 0.001 in. or 0.002 in. for the copper.

c Too great a clearance. This does not give correct support to the cutting edge, and the weak tungsten carbide cannot stand the strain. The clearance angles shown in Fig. 2 have been found satisfactory for average work.

d Chatter. This may be caused by loose bearings on the machine tool, by shanks too light for the cut, by improper support to the tool, by incorrect speeds and feeds for the material being cut, or by incorrect rakes and clearance angles on the tools. Any of these faults may be easily remedied, and are entirely within the hands of the shop using the material. If it is a slow chatter it does not do much harm, but if the chatter is of high frequency it is usually disastrous to the tool.

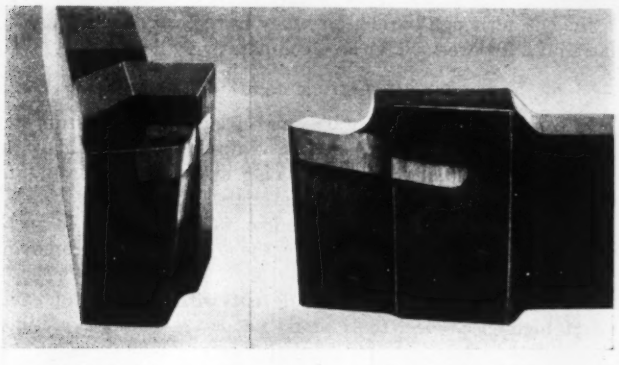


FIG. 8 SPECIAL TYPE OF TOOL FOR GENERAL WORK

e Not relieving the feed when breaking through the end of the cut. This applies to boring and turning where the cut is heavy and the material hard. The feed should be lessened as the tool is about to run out of the cut, otherwise when the tool first breaks through the spring in the shank will be relieved and the effect will be to increase the feed suddenly, tending to cause excessive pressure and tip breakage. On heavy cuts of this kind, the operator will do well to lessen the feed at this point.

f Heavy feeds on intermittent cuts. For instance, a square piece of work on a boring-mill table should not be roughed with a heavy feed until the cut becomes continuous. The gap between cuts will allow the feed to accumulate and cause too great a shock when the tool strikes.

g Improper grinding producing a rounded cutting edge, or one that is nicked and not smooth.

h Work not rigidly clamped or properly supported, causing vibrations.

EXAMPLES OF SUCCESSFUL APPLICATIONS

1 *Planing Large Gear-Ring Segments on 72 × 72-In. Planer.* Tool used, 2 × 2$^1/_2$ × 18-in. G55A Carboloy dovetail. Material cut, semi steel, 70 per cent steel scrap, 2 per cent nickel, Brinell hardness about 200, except scale, which was much harder. The surface had some sand, and there were a few blowholes just under the surface.

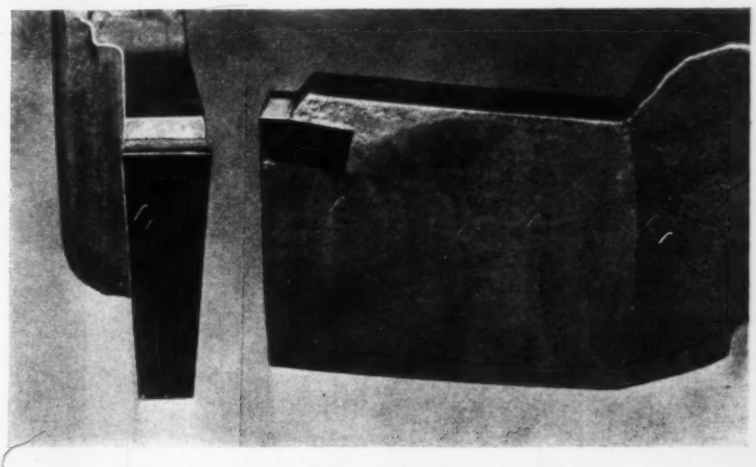


FIG. 9 FINISHING TOOL

The shape of the piece made it difficult to clamp securely, and there was some vibration.

Depth of cut, 1$^5/_{16}$ in. the entire depth of the tip; feed, $^3/_{32}$ in. and $^1/_8$ in.

Speed, 25 ft. per min. on short stroke (this could not be increased as the stroke was only a few inches, not allowing the planer table to come up to speed) and 52 ft. per min. when stroke reached 4 ft. or over. This latter was the maximum speed of the machine.

The surface condition of the material cut was so bad that high-speed-steel tools would not last more than a few minutes. It would have taken about 50 tools to finish the job, and about 49$^1/_2$ hours. The tungsten carbide tool required but 2 grinds and was still in good condition at the end. The time was 39 hours, a saving of 10$^1/_2$ hours or 21 per cent.

2 *Planing 16-Ft. Boring-Mill Uprights Complete Except Fit to Bed on 72 × 72-In. Planer.* Tool used, 2 × 2$^1/_2$ × 18-in. dovetail, as in first example. Various speeds and feeds were used on the several surfaces, with an average speed of 50 ft. per min. The chilled faces of these castings were impossible to cut with high-speed steel.

The pieces were finished in 45 hours as against a standard time (if these pieces had been machinable) of 66$^1/_4$ hours—a saving of 32 per cent.

3 *Planing Bed of Plate-Trimming Machine on 120 × 120-In. Planer* (Fig. 10). Tool used, 2 × 2$^1/_2$ × 14 in. The top surface shown in the illustration was roughed at 40 ft. per min., $^3/_{16}$ in. feed, $^5/_8$ in. average depth. The scale was bad and the cut intermittent.

There was no previous time to compare this with, but the time taken was less than estimated. Fig. 10 shows how the cut was interrupted by cored pockets. The photograph was taken after the first finishing cut, also with a tungsten carbide tool, using $^{7}/_{8}$ in. feed and 0.008 in. depth of cut with 40 ft. cutting speed. Fig. 11 shows a closer view of the same tool.

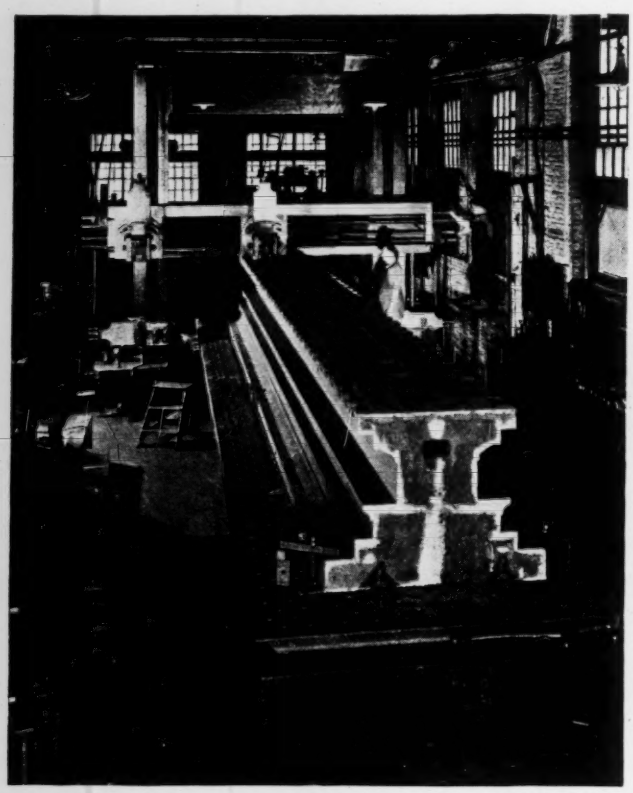


FIG. 10 PLATE-PLANER BED ON 120 × 120-IN. PLANER TABLE

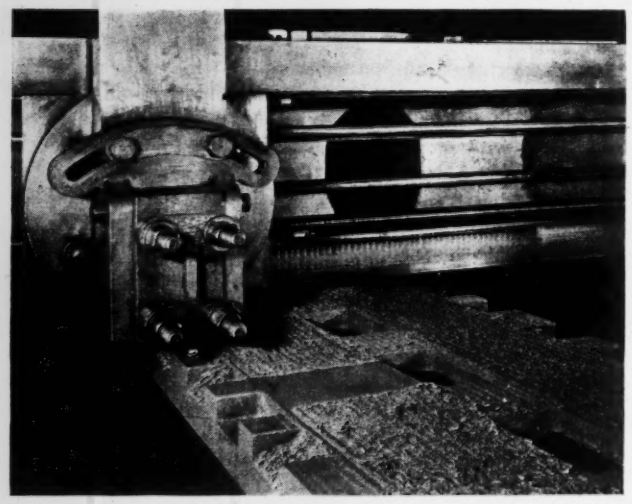


FIG. 11 VIEW OF TOOL USED ON PLANER IN FIG. 10

4 *Boring Long Half-Bearings Bolted Together on a 5-In.-Spindle Horizontal Boring Machine* (Fig. 12). Tools used, two $^{1}/_{2}$-in. bits inserted in special holder. Material cut, semi-steel (15 per cent steel), hard scale. Speed, 45 ft. per min. Feed, 0.033 in. per rev. Depth of cut, $^{5}/_{16}$ in. Time per piece, 5 hours. Average time between grinds, $5^{1}/_{2}$ hours. Total saving in wages for 40 pieces, $178.40, sufficient to pay for the tools several times over. The tool used is shown in Fig. 13.

5 *Rough and Finish Turning and Facing Table of Boring Mill* (Fig. 14). Size of tools, 2 × $2^{1}/_{2}$ in. for roughing. Speeds: 65 ft. per min. for first roughing cut, $^{3}/_{32}$ in. feed, depth $^{5}/_{8}$ to $^{7}/_{8}$ in.; 85 ft. per min. for second roughing cut, $^{1}/_{8}$ in. feed, depth, $^{1}/_{4}$ in.; 65 ft. per min. finishing cut. The first cuts were heavy, and the metal was removed very rapidly. The saving in this operation was $14^{1}/_{2}$ hours or 31 per cent.

6 *Planing a Floor-Boring-Machine Bed on a 60 × 60-In. Planer.* The ways which are being cut in Fig. 15 were chilled to get a close-grained iron. Previous practice permitted not over 24 ft. cutting speed. High-speed steel was first tried, but failed due to the hardness of the scale. The size of the tool was $1^{1}/_{2}$ × 3 × 14 in. The cut shown in the illustration was taken at a speed higher than 45 ft. per min., with $^{1}/_{8}$ in. feed (average) and $^{3}/_{4}$ in. depth. During the cut the motor fuse was blown three

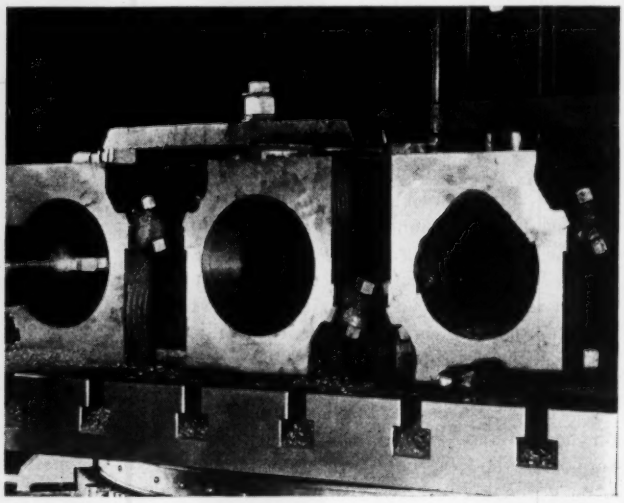


FIG. 12 BORING HALF-BEARINGS ON A HORIZONTAL BORING MACHINE

times. Both tools were in good condition after the cut. It is interesting to note that the tools did not break when they stopped in the cut, although some injury may have been done as the tips came off a few weeks later on a comparatively light cut.

CONCLUSIONS

In conclusion, the advantages and disadvantages of tungsten carbide cutting tools may be summed up as shown so far by the company's experience. The following apply to cast iron, and may or may not apply to other materials.

The foremost advantage, of course, is the increase in speed possible with the same feeds and depths of cuts, thereby removing more metal in a given time.

Sand and scale may usually be cut without harmful effect where high-speed-steel tools would not cut. This makes tungsten-carbide advantageous for use on large castings, where the great heat given off in pouring heavy sections tends to burn the sand and imbed it in the surface of the iron. Scale up to a hardness of 700 Brinell has been cut in the shop. Above that the tungsten carbide breaks down and the cutting edge becomes damaged.

Hard castings where, through some slip in the cupola charge or other cause, the iron has turned out too hard for the usual cutting materials, may be salvaged without returning it to the foundry for annealing or sending it to the scrap pile.

In long finishing cuts a further advantage is obtained by

reason of the fact that the tungsten carbide tool maintains its size throughout the entire operation. Much time is lost by even slight wear on a tool in the middle of such a cut, necessitating changing the tool and possibly starting the cut over again.

Among the foremost disadvantages should be mentioned the high cost of the tools and the increased cost of grinding.

The lack of strength of tungsten carbide makes it necessary to handle the tools with care. If they be dropped on a hard floor or knocked against a casting there is danger of chipping or cracking the tip. Abuse through taking too heavy a cut or in other ways already described may ruin a valuable tool.

There are many cases where there is no advantage obtained and where using tungsten carbide tools is a needless expense. This refers particularly to cuts which are already at the limit of

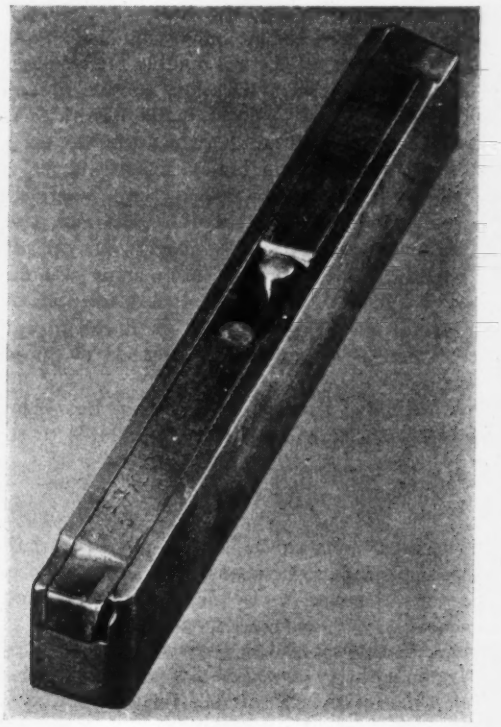


FIG. 13 TOOL USED ON BORING MACHINE IN FIG. 12

power of the machine tool. Unfortunately many shops have tools which were built at a period before production reached its present great heights. These prevent their owners from making full use of this remarkable material.

Tungsten carbide is yet in the stage of development. However, judging from its first year and a half of progress, it seems sure of a bright future. The material is being steadily improved and the weaknesses overcome as they are established. Six months ago the author would have numbered among its disadvantages the difficulty of properly brazing it and the non-uniformity of the material. Today these are relatively unimportant and they rarely cause trouble. Milling cutters and drills will be developed further, and machine tools will be designed to take full advantage of the qualities of tungsten carbide. However, the material will never be a panacea, and every one should use judgment in introducing it in his shop.

It is interesting to note that it took about a year to entirely overcome the opposition of the men in the Sellers shop. The early troubles made many of them afraid to use it at first. Now they consider it indispensable, and complain bitterly if the tools are not available when wanted.

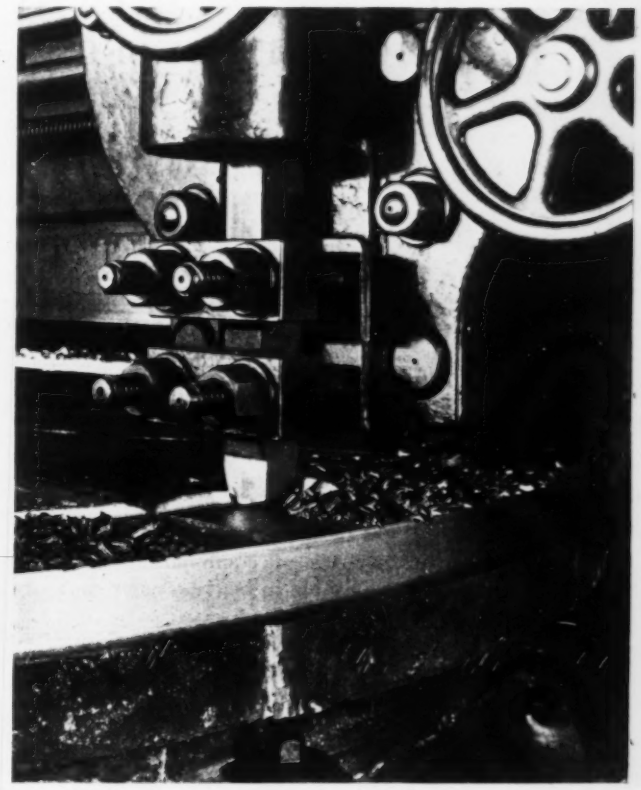


FIG. 14 FACING A BORING-MILL TABLE

FIG. 15 PLANING THE CHILLED WAYS ON A FLOOR-BORING-MACHINE BED

Heat Transmission Between Fluids and Solids: Conduction and Convection

By W. H. McADAMS,[1] CAMBRIDGE, MASS.

This paper deals primarily with the individual coefficients of heat transfer between solids and fluids. There are three classical methods of attack: (1) the mathematical, based on the differential equations of hydrodynamics and heat conduction; (2) the Reynolds analogy between heat transfer and fluid friction; and (3) dimensional analysis. Each method is discussed, and limitations introduced by the various assumptions are indicated. Data are given to illustrate the effect of heat transfer on friction.

A graphical method of obtaining individual coefficients of heat transfer from the overall coefficients is outlined, and some precautions advisable in heat-transfer measurements are listed.

The work of the National Research Council Committee on Heat Transmission is outlined, and their official symbols for heat transfer are tabulated.

DUE to the fact that heat transmission plays an important role in so many different types of industrial processes, there has been considerable interest in this field, as evidenced by the voluminous literature on the subject. One of the most important problems is the prediction of the rate of heat transmission by conduction and convection between a fluid and a solid under a given set of conditions, using the equation

$$q = hA(\Delta t) \quad \ldots\ldots\ldots [1]$$

As a result many attempts have been made to develop equations for predicting the coefficient of heat transfer, h, from the physical properties of the fluid, the configuration of the apparatus, and the mean velocity of the fluid past the heat-transfer surface. For turbulent flow of a fluid past a solid it has long been known that, in the immediate neighborhood of the surface, there exists a relatively quiet zone of fluid, commonly called the "film," and that a considerable fraction of the total drop in temperature, between the main body of the fluid and the solid surface, occurs in the film. In more recent years it has been recognized[2] that for *isothermal* conditions the flow in the film is still viscous in character, and the outer boundary of the film is now commonly defined as characterized by some critical value of the Reynolds number, $DV\rho/\mu$. For convenience in visualization, it is often assumed that the temperature gradient is wholly confined to the film flowing in viscous motion, although due to the lack of perfect mixing in the main body of the fluid, this assumption is not exact.[3] However, in spite of this simplification, the use of a film concept is of considerable value.

In attacking the problem of predicting the coefficient of heat transmission, several different methods have been used. The first is a strictly mathematical method based on the differential equations[4] of hydrodynamics and heat conduction. Due to the complexity of the equations, simplifying assumptions are introduced prior to integration, thus limiting the results obtained. One of the most popular simplifications consists in ignoring the viscosity of the fluid, and, as a result, the integrated equations so obtained[5] in general fall far short of fitting the experimental data, although under certain limited conditions the equations so obtained give results closely agreeing with experimental data. For the case of heat transfer between wires and gases, King[6] followed this method of attack, assuming that the thickness of the gas film varied in an arbitrarily chosen manner with position on the perimeter. In view of the assumptions made,[7] this theoretical equation agrees surprisingly closely[8] with experimental data. In spite of obvious difficulties, this method of approach still offers promise.

Another method of attack is the use of the Reynolds analogy[9] between heat transfer and friction, which leads to the simple equation:

$$h = fcG/2 \quad \ldots\ldots\ldots\ldots\ldots [2]$$

wherein consistent units are employed. Since the friction factor f increases with increase in viscosity, Equation [2] states that h increases with increase in viscosity, which is known to be untrue for liquids. For fluids of low viscosity, such as gases, this equation gives remarkably close agreement with the experimental data; for water the predicted results are of the right order of magnitude, but for the viscous oils the equation gives results far in excess of experimental data. A somewhat improved form of Equation [2] has been proposed by Schiller and Burbach[10] but is subject to the same general limitations mentioned above.

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[2] Stanton, Marshall, and Bryant, Proc. Roy. Soc. of London, vol. 97A (1920), p. 413.

Presented at the Second Plenary World Power Conference, Berlin, Germany, June 16–25, 1930.

[3] Pannell, Tech. Rep. Brit. Adv. Comm. for Aeronautics, Rep. and Mem. no. 243, vol. I, part 2 (1916–17).

[4] Fourier, Mem. de l'Acad., vol. 12 (1833), p. 507. Poisson, "Theo. Math. de la Chaleur," Bachelier, Paris, 1835. Ostrogradsky, St. Pet. Ac. Sc. Bull., no. 1 (1836), p. 25. "Oeuvres de Fourier," Edited by Darboux, vol. II, p. 595, Gauthier-Villars, Paris, 1890. Leveque, "Les Lois de la Transmission de Chaleur par Convection," *Annales des Mines*, vol. 13 (1928), series 12, pp. 201–381.

[5] Graetz, Ann. der Phys., vol. 18 (1883), p. 79; vol. 25 (1885), p. 337. Boussinesq, *Jl. Math. Pur et Appl.*, vol. I (1905), pp. 285–332. Russell, Proc. Phys. Soc. of London, vol. 22 (1909–1910), p. 445; *Phil. Mag.*, vol. 20 (1910), p. 591.

[6] King, Phil. Trans. Roy. Soc. of London, vol. 214A (1914), pp. 373–432.

[7] See Stanton, Tech. Rep. British Adv. Comm. for Aeronautics, Rep. and Mem. no. 94, appendix (1912–1913), p. 45. Morris, *Engineering* (London), vol. 96 (1913), p. 178. Rubach, Forsch, V.D.I., no. 135 (1916).

[8] Chappell and McAdams, Trans. A.S.M.E., vol. 48 (1926), p. 1201.

[9] Reynolds, Proc. Manchester Lit. and Phil. Soc., vol. 8 (1874); "Scientific Papers of Osborne Reynolds," Cambridge Univ. Press (1901), vol. I; Trans. Roy. Soc. of London, vol. 158, Part 2 (1883), p. 51; Stanton, Phil. Trans., vol. 190A (1897), p. 67.

[10] Schiller and Burbach, *Phys. Zeit.*, vol. 29 (1928), p. 340.

Apparently the best published modification of the Reynolds equation is that suggested by Prandtl[11] in 1910, and later by Taylor.[11a]

$$h = \frac{fcG/2}{1 + r\left(\frac{c\mu}{k} - 1\right)} \quad \text{.....[3]}$$

This calls for r, the highest velocity of the film flowing in viscous motion, divided by the average velocity of the fluid over the entire cross-section. Employing for f the value f_i obtained under isothermal conditions, Stanton[12] finds that a value of r of approximately 0.3 brings the "Taylor" formula into reasonably close agreement with certain heat-transfer data for water. For oils the Prandtl equation agrees better with experimental data

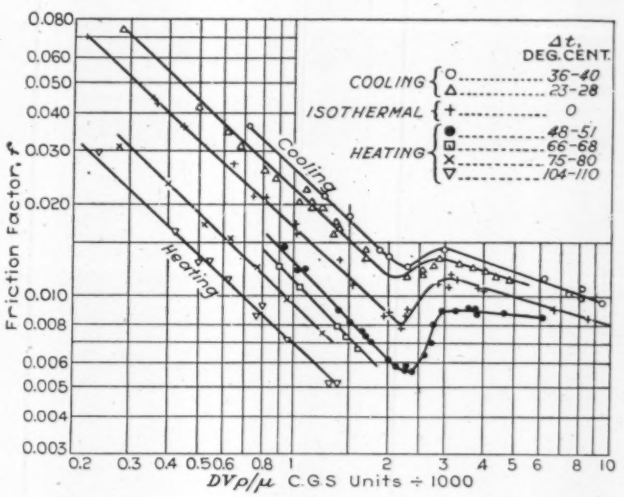

FIG. 1

than that of Reynolds. Thus, in employing these relations, the possible effect of heat transfer on friction is ignored.

Based on theoretical considerations, it has recently been shown[13] that heat transfer should affect fluid friction. This effect is due to the variation of viscosity with temperature, and the consequent influence upon velocity distribution, which in turn determines fluid friction. Preliminary experiments with oils have been made to test out these predictions, and the results are shown in Fig. 1. In using the Reynolds or Prandtl equation for predicting h, it is customary to evaluate f from a chart based on isothermal friction data, taking $DV\rho/\mu$ at the average temperature of the main body of the fluid. In order to show the errors so introduced, the observed values of f in Fig. 1 are plotted versus $DV\rho/\mu$ based on the average temperature of the main body of the fluid. On this basis, for liquids whose viscosities change rapidly with temperature, the apparent effect of heat transfer on friction is considerable in the region of modified viscous flow, $DV\rho/\mu$ <2100–2300 c.g.s. units, but in the turbulent range the effect seems to decrease considerably.

A third method of attack is based on the application of dimensional analysis, and this well-known method is of considerable value, although it is subject to limitations set by the assumptions as to the factors involved.

Following this method Nusselt[14] derived the following equation for the warming or cooling of fluids flowing inside pipes:

$$\frac{hD}{k} = \Phi\left(\frac{DV\rho}{\mu}\right), \psi\left(\frac{c\mu}{k}\right) \quad \text{.....[4][15]}$$

This is called the "original" Nusselt equation, to distinguish it from his equation for gases. Rice,[16] Morris and Whitman,[17] Cox,[18] and others have recently used Equation [4] in correlating experimental data. In an admirable experimental research, Nusselt firmly established that the functions of V and ρ were equal over a pressure range of 1 to 16 atmospheres for air, and over a lower pressure range for carbon dioxide and illuminating gas. As a result of this work, practically all valuable recent heat-transfer equations for warming and cooling gases employ the mass velocity term G, which equals $V\rho$. This name, "mass velocity," was apparently introduced by Reynolds[19] in 1883 when he made his brilliant prediction of the importance of the term. From work with gases only, the utility of the term $\psi\left(\frac{c\mu}{k}\right)$ can hardly be established since it varies but little from one gas to another, as was pointed out by Nusselt.[14] This naturally suggests the use of liquids of high viscosity as a method of considerable promise in laying a firm experimental basis for a general equation for fluids inside pipes. Unfortunately, complications then arise due to the large variation in viscosity with temperature for most viscous liquids, and the difficulty of determining the proper average to be used.

For the free convection between fluids and solids, equations based on dimensional analysis are used by Davis,[20] Griffiths and Davis,[21] Rice,[16] Heilman,[22] and others.

Based on one or more methods of attack, the literature contains a very large number of equations purporting to apply to some general case, such as the warming and cooling of fluids flowing inside pipes. Such equations are extremely helpful and, when used within range of the variables supported by experimental data, are often quite reliable. Unfortunately, the majority of such general equations contain more factors than have been experimentally investigated, and in reality are scientific guesses, based on test data covering variations in fewer factors than are called for by the general equations.[23]

Individual coefficients of heat transfer between fluid and solid are of greater utility than overall coefficients from fluid to fluid, and many publications give only overall coefficients. In such cases the value of the data often can be increased by the use of the graphical method of E. E. Wilson,[24] which determines the individual coefficients from the overall values by plotting $1/U$ versus $1/V^{0.8}$. In this connection it is sometimes advisable[25] to replace the term $1/V^{0.8}$ by the term:

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[11] Prandtl, *Phys. Zeit.*, vol. 11 (1910), p. 1072.

[11a] Taylor, Tech. Rep. Brit. Adv. Comm. for Aeronautics, Rep. and Mem. no. 272, vol. II for 1916–1917, p. 423; see also Perry, "The Steam Engine," The McMillan Co. (1909), chap. 3.

[12] Stanton, "Dictionary of Applied Physics," The MacMillan Co., N. Y., 1922–23, p. 401; see also "Mechanical Properties of Fluids," Van Nostrand, N. Y., 1924.

[13] Keevil and McAdams, *Chem. & Met. Eng.*, vol. 36 (1929), p. 464.

[14] Nusselt, Mitt. u. Forsch, no. 89 (1910).

[15] Equation [4] is often erroneously referred to as the Boussinesq equation.

[16] Rice, *Ind. & Eng. Chem.*, vol. 16 (1924), p. 460; I.C.T., vol. 5, p. 234.

[17] Morris and Whitman, *Ind. & Eng. Chem.*, vol. 20 (1928), p. 234.

[18] Cox, Trans. A.S.M.E., vol. 50 (Jan.-April, 1928), p. 12.

[19] Reynolds, Phil. Trans., 1883.

[20] Davis, *Phil. Mag.*, vol. 40 (1920), p. 692; vol. 41 (1921), p. 899; vol. 43 (1922), p. 329; vol. 44 (1922), p. 920; vol. 47 (1924), p. 972; vol. 48 (1925), p. 285.

[21] Griffiths and Davis, Food Investigation Board, Dept. Sci. and Ind. Res. (Gt. Brit.), Special Report No. 9, 1922.

[22] Heilman, *Mech. Eng.*, vol. 51 (1929), p. 355.

[23] Shack, "Der Industrielle Wärmeübergang," Verlag Stahleisen, Düsseldorf, 1929.

[24] Wilson, E. E., Trans. A.S.M.E., vol. 37 (1915), p. 473. McAdams, Sherwood, and Turner, Trans. A.S.M.E., vol. 48 (1926), p. 1223; McAdams, *Chem. & Met. Eng.*, vol. 34 (1927), p. 599.

[25] R. J. S. Pigott, private communication.

$$\frac{D}{k}\left(\frac{\mu}{DG}\right)^n\left(\frac{k}{c\mu}\right)^m$$

The literature on heat transfer abounds with papers reporting experimental data, and in a number of cases the worker failed to avoid errors previously noted by another investigator, or collected incomplete data. Consider an experimental set-up involving the steady flow of a fluid through a single steam-jacketed tube. Obviously, all measuring instruments should be carefully calibrated. Naturally, surface temperatures of the tube will be measured at a number of points, but the temperatures so read may be subject to considerable error, as pointed out by Othmer and Coates.[26] To avoid undue disturbance at entrance and exit of fluid, straight, unheated sections of pipe, called "calming sections," are sometimes used. In such cases, precautions should be taken to avoid undue conduction of heat from the jacketed sections to these outside portions. This is sometimes done by making the calming sections of materials of very low thermal conductivity, such as bakelite or hard rubber, made to fit flush against the heated section. Especially in the case of viscous liquids, care should be taken to measure the average temperature of the fluids leaving the heated section, since the temperature measured at the center line will be too low. This is best done by the use of a properly designed mixing section. In order to give confidence in the data collected, it is advisable to make heat balances. For this reason dry steam should be used so that calculations may be based on the condensate, after correcting for losses experimentally determined in a blank run. The surface condition should be kept constant by a uniform procedure of cleaning, and in order to show that the results obtained are reproducible, a standard run should be repeated at reasonably frequent intervals. This is especially important when high coefficients of heat transfer are to be measured.[27] Finally, it is very important to determine pressure-drop data during both the heat transmission and isothermal runs. The literature now contains few papers where pressure-drop data have been collected during heat-transfer experiments. The importance of having data thus obtained lies in the fact that the designer of apparatus later wishes to make an economic balance between power costs and fixed charges to determine the optimum design of apparatus.[28]

A few years ago the National Research Council Committee on Heat Transmission was organized.[29] As a result a research program has been mapped out and several fellowships are in operation. From time to time the Committee publishes a directory of current research in heat transmission, so that the workers in this field may keep in touch with one another. At the present time two textbooks are being prepared under the auspices of the Committee. Standard symbols and nomenclature have been adopted both by this Committee and by the American Standards Association,[30] as shown by the following list:

Area	A
Temperature, fahrenheit or centigrade	t
Temperature, fahrenheit absolute or Kelvin	T
Length of path of heat flow, thickness	L
Total quantity of heat transferred	Q
Time (when t is used for temperature)	τ
Thermal transmission (heat transferred per unit time)	q

$$q = Q/\tau$$

Thermal conductivity (heat transferred per unit time per unit area and per degree per unit length)	k
Thermal resistivity	$1/k$
Thermal resistance (degrees per unit of heat transferred per unit time)	R
Thermal conductance (heat transferred per unit time per degree)	C
Thermal conductance per unit area, sometimes called "unit conductance" (heat transferred per unit time per unit area per degree)	C_A
Surface coefficient of heat transfer; film coefficient of heat transfer, individual coefficient of heat transfer (heat transferred per unit time per unit area, per degree). (In general h is not equal to k/L, where L is the actual thickness of the fluid film.)	h
Overall coefficient of heat transfer; thermal transmittance per unit area (heat transferred per unit time per unit area per degree overall)	U

NOMENCLATURE

In addition to symbols taken from the N.R.C. list, the following are used herein, expressed in c.g.s. units.

c = specific heat of fluid
D = inside diameter
f = friction factor in the Fanning equation for fluid friction: heat lost due to friction per unit length of pipe = $fV^2/2gm$, where m is the hydraulic radius
f_i = friction factor for isothermal conditions
G = mass velocity = $V\rho$
g = acceleration due to gravity
m, n = exponents, determined experimentally
r = ratio of linear velocity at interface between film and main body of fluid, to average linear velocity of main body
V = average linear velocity
μ = absolute viscosity of fluid
ρ = fluid density
ψ, Φ = functions
Δt = temperature difference between fluid and solid.

ACKNOWLEDGMENT

The author wishes to thank Dr. T. E. Stanton for helpful suggestions.

[26] *Ind. & Eng. Chem.*, vol. 20 (1928), pp. 124, 445.
[27] Pridgeon and Badger, *Ind. & Eng. Chem.*, vol. 16 (1924), p. 474.
[28] Lewis, Ward, and Voss, *Ind. & Eng. Chem.*, vol. 16 (1924), p. 467.
[29] W. V. A. Kemp, *Mech. Eng.*, vol. 51 (1929), p. 368.
[30] 29 West 39th Street, New York City.

Light-Beam Train Control

A NEW device is being tried out over a stretch of several hundred miles of the German State Railways, between Berlin and Munich. From a small searchlight on the front of the locomotive a narrow beam of light is thrown upward all the time the locomotive is in operation. A ring of light-sensitive cells are located around the searchlight lens. When the train comes to a signal post, the mirror on the post reflects the light back to one of the cells. This starts an electric current, which makes a visible signal in the engine cab, and remains until the engineer acts on it, or, if he does not respond promptly, the train is stopped automatically. Movement of the mirror on the post determines which cell receives the reflected light, and the signal given the engineer. In order that the wrong signal will not be given by some stray light beam, the light of the searchlight is interrupted 600 times a second by a rotating shutter, and the cells are adjusted to respond only to light of this frequency.—*Science News-Letter*, Jan. 25, 1930, p. 56.

Transmission of Heat Through Insulation

By R. H. HEILMAN,[1] PITTSBURGH, PA.

This paper contains a brief discussion of the views formerly held on the mechanism of heat transfer through insulation, together with a short discussion on the present views resulting from the latest researches on heat transfer and heat insulation.

The relative importance of the three modes of heat transmission—conduction, radiation, and convection—is discussed, and the conclusion is drawn that there is no transmission by convection through the commercial insulations so far manufactured.

For molded types of insulation where the air pockets are infinitesimally small, it is concluded that the transfer takes place entirely by pure conduction. It is also shown that the temperature coefficient for the conductivity of air is sufficiently high to account for the increase in conductivity with temperature of some of the molded types of insulation.

For corrugated types of insulation where the air pockets are very large, it is concluded that the transfer of heat by radiation is of considerable magnitude. Formulas are given showing the effect of radiation and conduction on heat transmission as a function of conductivity, pore diameter, and absolute temperature.

The effects of metallic paints when applied to the outer surfaces of heat insulation for the purpose of increasing the efficiency are also discussed.

Formulas and graphs are also included which enable one to readily determine the heat losses by radiation and convection from bare pipes, boiler walls, and other types of surfaces met in industry.

THE author has been requested to prepare a short paper on heat transmission dealing briefly with the views formerly held as to the mechanism of heat transfer through heat insulation, as well as the conceptions which we now have of the mode of heat transfer resulting from the latest researches on heat transmission and heat insulation.

This paper is therefore a very brief discussion of the relative importance of the three modes of heat transmission—conduction, radiation, and convection—as applied to heat insulation.

The author is responsible for some of the conclusions included in the paper, and will welcome correction where his judgment is in error.

Engineering units are used in this report. Conductivity is expressed in B.t.u. per hr. per sq. ft. per in. per deg. fahr.

Former Views on Mode of Transmission

The transfer of heat through insulating materials was formerly believed to take place mostly by conduction and convection, with possibly a small percentage by radiation, the popular opinion being that any material which entrapped large quantities of dead air spaces would constitute a good insulating material. The geometrical shape of the particles composing the insulation was also supposed to be of considerable importance.

It was believed that the highest insulating value was obtained from materials in which the particles of solid matter were composed of needle-like crystals having very small points of contact with adjacent crystals. The small cross-sectional area of the crystal would decrease the path through which the heat could flow by conduction, and the small points of contact from one solid particle to another would offer an added surface resistance which would still further decrease the heat flow. These internal surface resistances were believed to be highly important.

In purchasing heat-insulating materials, the material having the lowest apparent density was usually given the preference.

The relative importance of the various items mentioned above was little understood or appreciated, with the consequence that many crude and inefficient types of heat insulation were in use.

However, the knowledge gained from scientific investigations on the subject of heat transmission, which includes the effects of radiation and conduction, especially at high temperatures, has enabled the manufacturer to produce heat insulations capable of withstanding very high temperatures with an efficiency much higher than was formerly considered possible.

A brief discussion of the relative importance of conduction, radiation, and convection through insulating materials follows.

Conduction

With the exception of those insulating materials which have large pore spaces, heat is transmitted through insulation mainly by conduction. Space does not permit a lengthy discussion on the various molecular and electron theories of heat conduction. However, these theories seem to indicate quite clearly that the rate of propagation of heat depends on the nature of the molecules composing the substance, so that the conductivity would be expected to vary considerably in different substances.

These suspicions have been amply verified by conductivity tests on metals and also on heat-insulating materials. The tests on metals have shown that conductivity is not related to density—for instance, aluminum has a conductivity value approximately 6 times that of lead, while the specific gravity is approximately 4.5 times lower. Also the conductivity of lead is about 11 times lower than copper, while the specific gravity is about 1.3 times higher. The conductivity of insulating materials is usually considered to depend upon the bulk density of the material. However, tests have shown that this is not always so. For instance, conductivity tests on two powdered materials indicated that one recently discovered material had a conductivity value somewhat lower than a well-known insulating powder, although the apparent density was approximately 3 times as much.

However, the bulk density of a given material has considerable bearing on the conductivity. Many dense materials having practically no insulating value, when transformed by chemical processes into light, fluffy materials, attain high insulating values, although chemically no change has taken place in the composition of the materials. The increased insulating value is probably due to the infinite number of exceedingly small air pockets created by the chemical action.

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Presented at the Second Plenary World Power Conference, Berlin, Germany, June 16–25, 1930.

Materials such as magnesia, which has over 85 per cent porosity, have exceedingly small air pockets so that the heat is transmitted through the insulation practically entirely by pure conduction across the pore spaces and by pure conduction through the magnesia particles themselves.

The importance of the pure-conduction coefficient of air is often not realized. Even at comparatively low temperatures the average velocity of the molecules in air is very high, so that the heat transmitted across the air space by this tremendous bombardment is comparatively high.

The conductivity of air at 0 deg. cent. has been found to be approximately 0.000057 in c.g.s. units.

Since the average velocity of the molecules in air increases with increase in temperature, the conductivity of air increases with increase in temperature, the temperature coefficient per degree centigrade being 0.0029 as found by Eukens, or k for air $= k_0(1 + 0.0029t)$.

Therefore the conductivity of air in engineering units at 32 deg. fahr. = 0.166 and at 300 deg. fahr. = 0.237 B.t.u. per hr. per sq. ft. per in. per deg. fahr.

This increase in conductivity of air with temperature is sufficient to allow for the total increase with temperature of the conductivity of some molded insulations.

It is very probable that the conductivity of the material composing the insulation also has some positive temperature coefficient, although the temperature coefficient is negative for metals.

The former belief that the increase in conductivity of all heat-insulating materials with temperature was due to radiation and convection is probably unfounded, with the exception of course of those having extremely large air pockets, where radiation becomes very important.

It is rather hard to indicate at this time the relative importance of internal contact resistances, although the author is inclined to believe that they are not nearly as important as suspected.

RADIATION

The heat transmitted by radiation across the pore spaces in an insulation depends largely upon the diameter of the pore spaces in the direction of the heat flow. Since the radiation is proportional to the difference of the fourth powers of the absolute temperatures, it is readily apparent that only where the pore spaces are comparatively large or where the temperature drop across the spaces is comparatively great, will the loss by radiation be of much importance.

A rough approximation of the effect of reducing the size of the pores in an insulation can be seen from the following.

If we take an air space bounded by two planes, neglecting conductivity, etc., the heat transfer by radiation for an emissivity value of 1 for the bounding surfaces is given by the Stefan-Boltzmann equation as

$$R = C(T_1^4 - T_0^4) \quad [1]$$

If we divide the air space into two equal parts with another plane, since the heat transmitted must be the same through each space, we have

$$R_1 = C(T_1^4 - T_2^4) = C(T_2^4 - T_0^4) \quad [2]$$

or

$$T_2^4 = \frac{T_1^4 + T_0^4}{2}$$

Substituting in [2] the value of T_2^4,

$$R_1 = C\left(\frac{T_1^4 + T_0^4}{2} - T_0^4\right) = {}^1/_2C(T_1^4 - T_0^4) \quad [3]$$

which indicates that the use of a baffle in the center of an air space will cut down the radiation by approximately one-half.

If we divide the air space into three equal parts,

$$R_1 = C(T_1^4 - T_2^4) = C(T_2^4 - T_3^4) = C(T_3^4 - T_0^4) \quad [4]$$

whence

$$(T_1^4 - 2T_2^4 + T_3^4) = 0, \text{ and } (T_2^4 - 2T_3^4 + T_0^4) = 0$$

or

$$T_2^4 - T_3^4 = {}^1/_3(T_1^4 - T_0^4)$$

whence

$$R_1 = {}^1/_3C(T_1^4 - T_0^4) \quad [5]$$

It is therefore apparent that the use of one baffle will reduce the radiation by approximately one-half, that the use of two baffles will reduce it to approximately one-third, and so on.

In the case of some of the insulations such as magnesia having extremely small subdivisions—probably thousands per inch of thickness—it is apparent that the amount of heat transmitted through the insulation by radiation is practically zero. However, in the case of deeply corrugated insulations such as air cell, the heat transmitted by radiation is relatively very great.

The ratio of the heat transmitted by radiation to that by conduction through an insulating material can be roughly approximated by the method suggested by Doughill, Hodsman, and Cobb[2] for refractory materials. Comparing the transmission of heat by conduction across a parallel-faced slab of solid material to that of a similarly shaped air space, when the two parallel faces are in each case at T_1 deg. and T_2 deg., absolute, the quantity of heat transmitted by conduction across the solid per square foot per hour per unit thickness $= k(T_1 - T_2)$ B.t.u., and by radiation across a pore of the same thickness $= 17.23 \times 10^{-10}(T_1^4 - T_2^4)$ B.t.u.

When the transfer of heat by radiation equals that by conduction, we can equate these, giving

$$\frac{k(T_1 - T_2)}{L} = 17.23 \times 10^{-10}(T_1^4 - T_2^4) \quad [6]$$

where L denotes the thickness or diameter of pore.

From Equation [6] it is easy to determine at what temperature the radiation and conduction are equal, bearing in mind that for small pore spaces $(T_1 - T_2)$ would be small compared with T_1 or T_2. Designating $(T_1 - T_2)$ by Δt, then

$$\frac{k}{L}\Delta t = 17.23 \times 10^{-10}[(T_2 + \Delta t)^4 - T_2^4] \quad [7]$$

Neglecting the higher terms of Δt,

$$\frac{k}{L}\Delta t = 17.23 \times 10^{-10} \times 4\Delta t \times T_2^3$$

whence

$$T_2^3 = \frac{k \times 10^9}{6.89\,L}$$

or

$$T_2 = 10^3\sqrt[3]{\frac{k}{6.89\,L}} \quad [8]$$

If we take four-ply air cell in which there are 4 air cells approximately 0.2 in. in depth for a covering 1 in. in thickness, and assume a conductivity of 0.8 for the asbestos paper, we have

[2] "Thermal Conductivity of Refractory Materials." *Jl. Soc. Chem. Ind.*, vol. 34 (1915), pp. 465–471.

$$T_2 = 1000 \sqrt[3]{\frac{0.8}{6.89 \times 0.2}} = 834 \text{ deg. abs. or } 374 \text{ deg. fahr.}$$

which indicates that for temperatures up to approximately 374 deg. fahr., the corrugated construction is more efficient than the same thickness of solid asbestos having a conductivity of 0.8 B.t.u.; it is also much lighter in weight and costs considerably less to manufacture.

The ratio r of the heat conducted by a solid grain to that radiated across a pore for various diameters of pores, absolute temperatures, and conductivities of solid material, is given by

$$r = \frac{1.45\ k \times 10^8}{L\ T_2^3} \quad \ldots\ldots [9]$$

CONVECTION

The amount of heat transmitted by convection across the pore spaces in heat-insulating materials is in practically all cases essentially zero. Tests conducted at Mellon Institute on corrugated asbestos coverings having corrugations slightly greater than 0.1 in. indicated that there were no convection currents in the pore spaces. The test apparatus was set up in such a way as to eliminate all flow of heat upward but with free flow downward. In this case there could be no heat transmitted through the insulation by convection. The flow of heat was then reversed, allowing the heat to flow upward through the insulation. Heat-loss curves plotted from the results of the two tests which were conducted over a considerable temperature range were found to coincide, thus proving that no heat flow took place by convection.

In a second test two four-ply-per-inch corrugated coverings, one having the corrugations closed every 3 in. and the other having the corrugations open the entire length of the section, were tested on both horizontal and vertical pipes. These tests indicated that there was no flue action in the covering having the unbroken corrugations extending for the 36-in. length of the covering when placed on a vertical pipe. It is therefore apparent that for rough surfaces, such as asbestos paper, the height of the corrugation has no effect on the convection for air spaces up to 0.2 in. in diameter. Perhaps this is due to the fact that the motionless film of air which is believed to adhere to any heated surface is probably greater than 0.1 in. in thickness. This would prevent any air motion up one side of the insulation and down the other.

From the results of the above-mentioned tests it can be concluded that there is no heat transfer by convection through an insulating material having pore spaces equal to or less than 0.2 in. in diameter. This limitation in size probably includes all insulations now on the market.

DECREASING HEAT LOSSES BY USE OF METALLIC PAINTS

The author has recently visited several plants where the canvas jackets of the pipe covering are painted with aluminum paints for the purpose of decreasing the heat losses as well as for appearance and protection for the jacket itself.

Since there seems to be considerable misunderstanding in regard to the use of metallic or bronze paints, a brief discussion of this item is included in this paper. Since the greater part of the heat loss from the canvas surface takes place by radiation, and since the emissivity of bronze paint on a canvas jacket is much lower than the emissivity of the canvas itself, it is often believed that the use of the bronze paint will considerably decrease the total heat loss. However, the fact that the bronze paint will increase the surface temperature considerably is quite often neglected. The saving is therefore not as great as is usually suspected.

A concrete example will serve best to illustrate the method to use in determining the saving for any given condition.

For example, a 3-in. pipe operating at a temperature of 380 deg. fahr. is insulated with a 1-in. thickness of laminated asbestos pipe covering with a conductivity value of 0.432 B.t.u. at a mean temperature of 254 deg. fahr. The room temperature is 80 deg. fahr. What will the heat loss be with an unpainted jacket, and also with the canvas jacket when painted with aluminum paint?

In order to calculate the heat loss through the insulation, it is first necessary to know the temperature of the canvas jacket, or the heat loss from the jacket as a function of the temperature difference between the jacket and surrounding air. An approximate empirical equation for this relation has been determined by the author as follows:

$$\Delta t = \frac{272.5q}{q + \frac{564}{D^{0.19}}} \quad \ldots\ldots [10]$$

Now the heat loss through a cylindrical insulation can be calculated from the formula.

$$q = \frac{k(t_1 - t_3 - \Delta t)}{r_2 \log_e \frac{r_2}{r_1}} \quad \ldots\ldots [11]$$

or

$$q = \frac{k(t_1 - t_2) - \frac{272.5\ q}{q + \frac{564}{D^{0.19}}}}{r_2 \log_e \frac{r_2}{r_1}} \quad \ldots\ldots [12]$$

Substituting the known values in Equation [12] and solving the resulting quadratic,

q = 87.6 B.t.u. per sq. ft. of canvas surface

Also Δt = 48 deg. fahr., whence the canvas temperature = 128 deg. fahr.

In order to separate the canvas-surface loss into its two components radiation and convection, it is necessary to know the emissivity value of the canvas surface and also to have an equation for the free convection. Experiments conducted by the author with the aid of a very sensitive radiometer indicated emissivity values of 0.94 to 0.98 for unpainted canvas at temperatures of 100 deg. fahr. to 200 deg. fahr. Taking the mean value of 0.96 for a canvas temperature of 128 deg. fahr., the heat loss by radiation from the Stefan-Boltzmann formula is

$$R = 17.23 \times 10^{-10} \times e(T_1^4 - T_2^4) \quad \ldots\ldots [13]$$

or

$$q_r = 17.23 \times 10^{-10} \times 0.96(588^4 - 540^4) = 57 \text{ B.t.u.}$$

An equation giving the loss by free convection from various geometrical shapes as determined from a large number of tests is

$$q_c = CA \left(\frac{1}{D}\right)^{0.2} p^{0.533} \left(\frac{1}{T_{avg.}}\right)^{0.181} \Delta t^{1.266} \text{ B.t.u. per sq. ft. per hr.} \quad \ldots [14]$$

The value of C for the various shapes as determined by the author[3] and various investigators are

Horizontal cylinders	1.016
Long vertical cylinders	1.235
Vertical plates	1.394

[3] Trans. A.S.M.E., vol. 51 (1929), no. 22, p. 287.

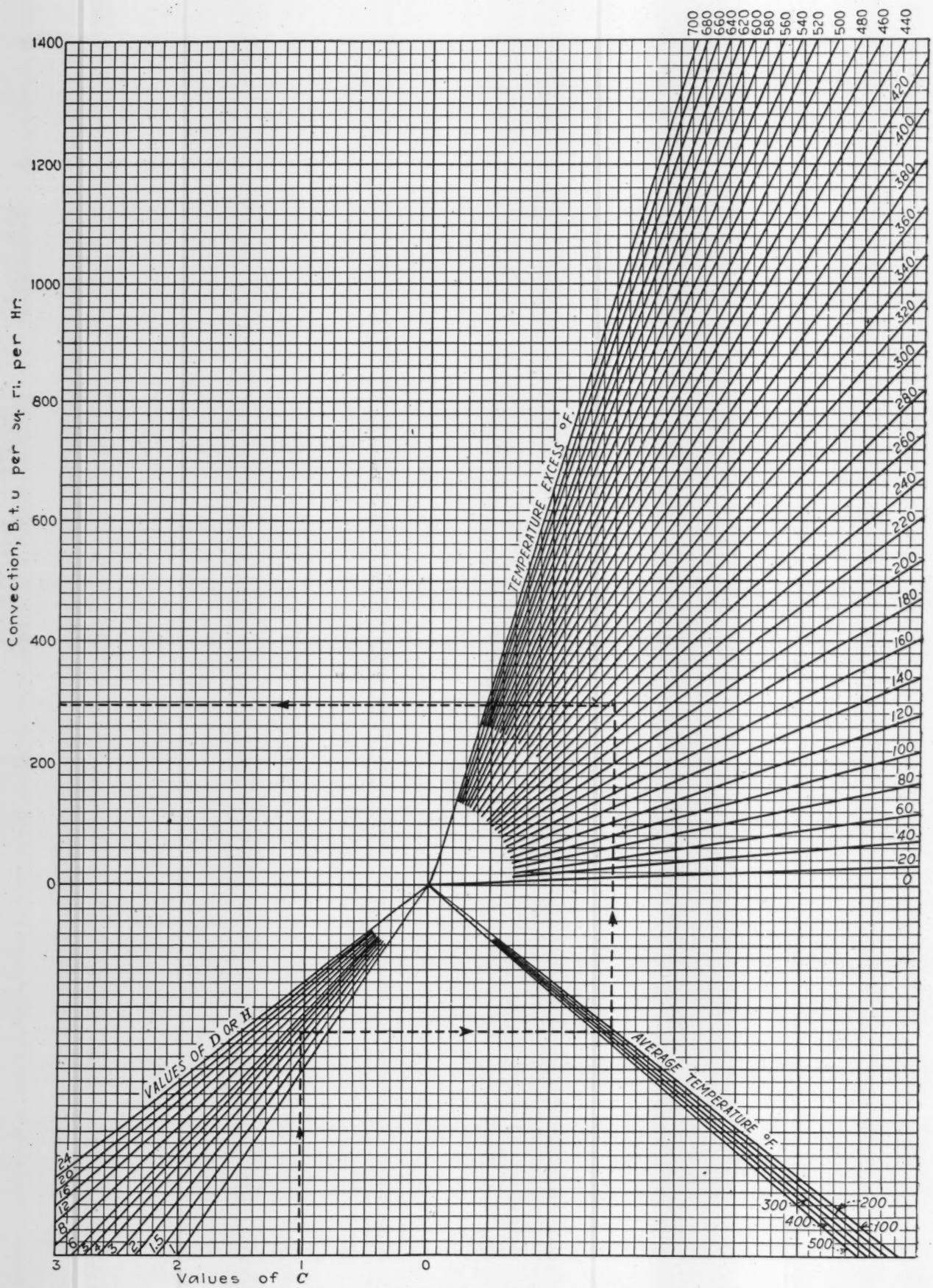


FIG. 1 HEAT TRANSMITTED BY CONVECTION

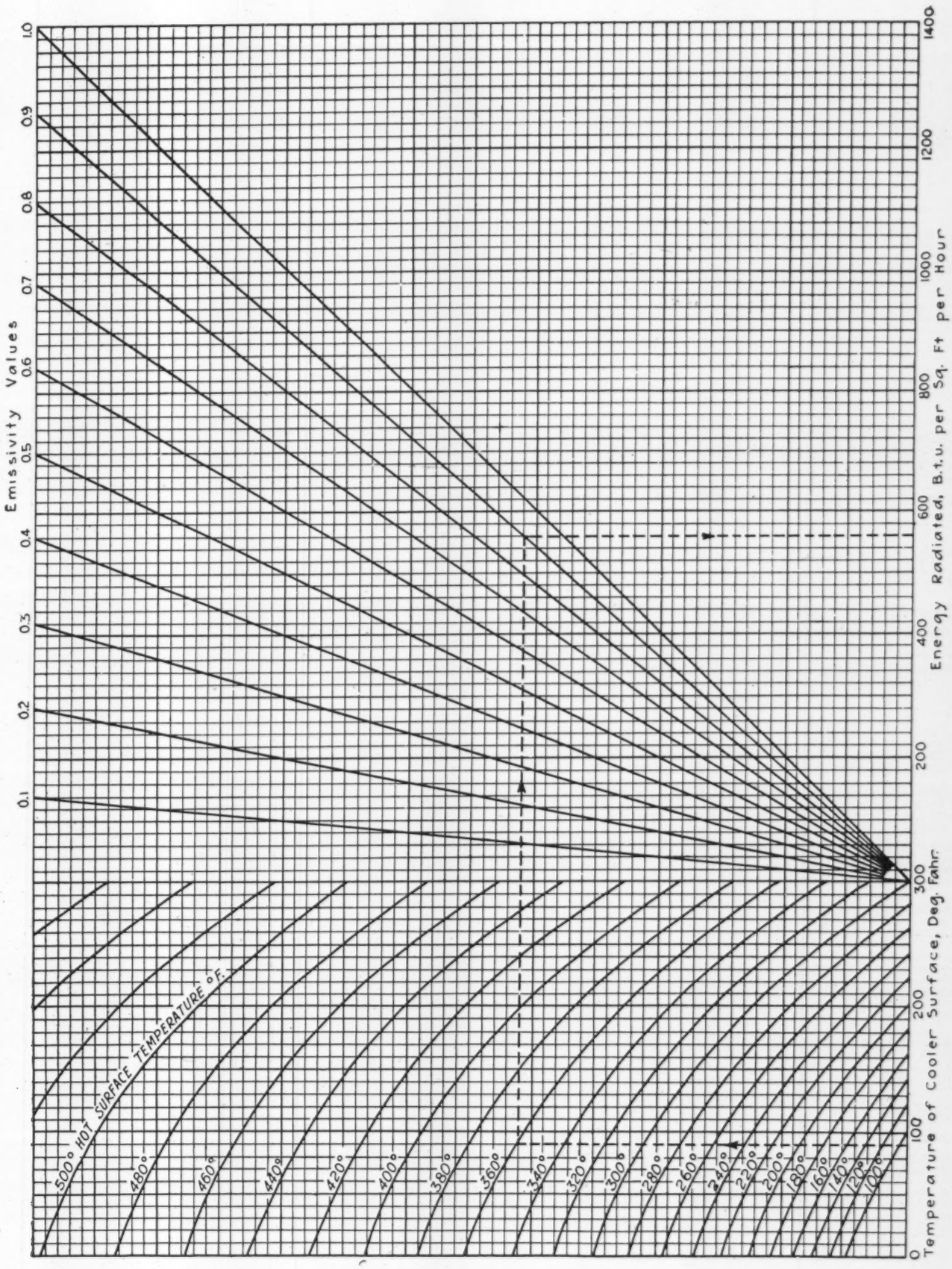


FIG. 2 HEAT TRANSMITTED BY RADIATION

Horizontal plates facing upward	1.79
Horizontal plates facing downward	0.89
Spheres	1.82

The heat loss by free convection from the canvas surface of the laminated covering is found to be

$$q_c = 1.016\left(\frac{1}{5.5}\right)^{0.2} \times \left(\frac{1}{564}\right)^{0.181} \times 48^{1.266}$$

$$= 30.9 \text{ B.t.u. per sq. ft. per hr.}$$

The total loss then from the two equations = 87.9 B.t.u., which checks very well with the value of 87.6 B.t.u. obtained by the use of the single empirical formula.

To obtain the loss from the bronze-painted canvas surface, it is necessary to use Equations [13] and [14] for radiation and convection, together with the formula for the heat loss through the insulation. Owing to the fact that the increase in the canvas temperature results in increasing the mean temperature of the insulation, which consequently increases the value of k, it is easier to determine the surface loss by trial, assuming values of t until the loss through the insulation checks with the loss from the surface.

The average emissivity value of aluminum paint applied to a canvas jacket was found to be 0.33. By trial, it is found that the canvas temperature will be approximately 151 deg. fahr. when painted with aluminum paint with the same conditions of pipe and room temperature.

The loss by radiation = $17.23 \times 10^{-10} \times 0.33 \times (611^4 - 540^4)$ = 30.9 B.t.u.; while the loss by convection = $1.016 \times (1/5.5)^{0.2} \times (1/575.5)^{0.185} \times 71^{1.266}$ = 50.5 B.t.u. The total loss from the aluminum-painted surface then = 81.4 B.t.u. per hr. Checking the loss through the insulation, we have, since the mean temperature of the insulation is now (380 + 151)/2 or 265.5 and $k = 0.44$,

$$q = \frac{0.44(380 - 151)}{2.75 \log_e \frac{2.75}{1.75}} = 81.2 \text{ B.t.u. per sq. ft. per hr.}$$

The saving by the use of the aluminum paint is therefore

$$\frac{87.6 - 81.2}{87.6} \times 100 = 7.3 \text{ per cent.}$$

On flat surfaces and installations where the surface temperatures are much higher, the use of bronze paint will result in much greater savings. Occasionally short lengths of steam pipes are left bare where repairs are often necessary, and in many cases great numbers of valves and fittings are left entirely bare. The use of bronze paint will result in enormous savings in such cases, since the pipe temperature will remain practically the same as the steam temperature and the full value of the lower emissivity can be obtained.

To enable one to readily determine the heat losses from various surfaces, charts are shown in Figs. 1 and 2, which have been plotted from Equations [13] and [14].

In using the radiation chart, a sufficiently close approximation will be obtained by employing an emissivity coefficient of 0.95 to 0.98 for most surfaces met in practice, such as iron and steel pipe, brick, stone, cement, wood, and other rough surfaces, with the exception of relatively smooth metallic surfaces or polished metals.

COMMITTEE ON HEAT TRANSMISSION

In order to improve the general knowledge and to coordinate the researches on heat transfer being conducted throughout the United States, the Committee on Heat Transmission, National Research Council, has undertaken an extensive program on all phases of heat transfer. Various committees have been appointed to assist in this program, and thus far one very excellent report on Definitions, Nomenclature, Symbols, and Units has been adopted.

Two test codes on the determination of thermal conductivities have been practically completed, and experimental work on other codes is now in progress.

At present the Committee has in operation three fellowships which are actively engaged in experimental determinations on heat transfer from oil to oil through metallic surfaces, on heat transfer between water in the liquid and vapor phase, and on heat transmission by radiation from luminous and non-luminous flames.

The work of the Committee is therefore highly commendable and should result in very valuable information.

Cosmic Rays

FOR many years it has been known that ordinary atmospheric air has a very slight but nevertheless measurable conductivity. This is attributable to the fact that at any given instant a very small fraction of the molecules of oxygen and nitrogen have been deprived of an electron, or ionized. The positive and negative ions so formed move under an applied electric field, and the air therefore conducts. Part of this ionization is no doubt due to terrestrial causes, such as the α, β, and γ rays which are emitted by radioactive substances on the earth's crust. Part of it, however, cannot be explained in this way, and it is this ionization of non-terrestrial origin with which we are now concerned. Millikan has found that the intensity of the radiation giving rise to this ionization increases with altitude, and is evidently coming from outside the earth. It does not, however, seem to come from any particular part of the stellar system, since it is the same by day and by night and at different seasons of the year. The radiation is, of course, absorbed by matter, as is shown by the fact that it decreases as it passes through the earth's atmosphere. Nevertheless it is very penetrating, being able to pass through as much as 57 meters of water or 5 meters of lead before it is completely absorbed. The nature and origin of these cosmic rays is unknown, though Millikan inclines to the theory that they are electromagnetic waves, similar in kind to light waves or X-rays, but of much shorter wave length. He calculates that if an electromagnetic wave of penetration equal to that of the most penetrating cosmic rays he has been able to detect were generated in an X-ray tube, the potential needed would be about 200 million volts. Such enormous energies as this cannot be expected from any radioactive elements, so that Millikan assumes the radiation to be the result of the transformation of matter into energy, in accordance with the relativity relation for the equivalence of mass and energy. To take a definite example, Millikan assumes that, somewhere in the depths of space, helium (the mass of whose nucleus is 4 units) is being formed by the combination of four electrons and four protons. Aston's work with the mass spectrograph, however, shows that when helium is formed out of the primitive units of protons and electrons there is a definite loss of mass. The energy equivalent of this loss of mass is calculated by Millikan to be just such as will give rise to radiation of the penetrating power which he actually observes. Similarly he considers that his cosmic rays as the by-product of a process of atom building which is going on in the depths of space.—L. G. Carpenter in *World Power*, March, 1930, p. 249.

Radiant Heat Transmission

By H. C. HOTTEL,[1] CAMBRIDGE, MASS.

The present status of our knowledge on radiant heat transmission is summarized by the author under three headings: (1) Radiation Between Solids, (2) Radiation From Clouds of Particles, and (3) Radiation from Clear Gases.

The first section is presented somewhat more in detail than the other two. The evaluation of radiant heat interchange between two surfaces involves the Stefan-Boltzmann equation, together with an angle factor which makes allowance for the finite extent of the surfaces involved. A table is presented in which the angle factor is given for seventeen different surface arrangements, thereby permitting almost any case to be evaluated in terms of one of the standard forms. For those cases in which the angle factor is a complicated function of the variables involved, plots are presented for convenience in making calculations.

In Section 2 the theoretical results on the problem of radiation from powdered-coal flames are presented, as well as the objections to them. Analytical and experimental results on the allied problem of luminous-flame radiation are summarized. In Section 3 the status of our knowledge of non-luminous-gas radiation is presented.

Problems which remain to be solved are presented in each of the three fields, together with mention of work now in progress in America on such problems.

THE dissemination among engineers of an adequate working knowledge of heat transfer by radiation has been hampered by a number of factors, chief among which are the incompleteness of our knowledge of the subject, the lack of organization of what knowledge we do have, the failure of the scientist to concern himself with the application of his specialized knowledge of radiation to radiant-heat-transfer calculations, and the hesitation of engineers to use some of the methods of calculation which have in the past been available because of their unwieldiness or complexity. It is the purpose of this paper to present briefly the status of the subject of radiant heat transfer, including recent developments which it is hoped will make the material more practically applicable; to indicate wherein our knowledge of the subject is incomplete; and to give a brief review of present activities in this field of research in America.

I—Radiation Between Solids

The development of heat-consuming industrial processes which demand for their safe or successful operation an exact knowledge of the distribution of heat input into the various parts of the heat-receiving surface, and the consequent demand upon engineers to predict furnace performance on paper with all of the accuracy that the most exact available methods of calculation will permit, have led to a growing interest in the subject of radiation between finite surfaces. There has been no adequate treatment of the subject, and although the principles involved are simple, their misuse in a number of contributions to the engineering literature has not assisted in clarifying the picture.

Radiant heat interchange between finite surfaces may be evaluated by starting with the Stefan-Boltzmann law, Kirchoff's law, and Lambert's cosine principle, the problems involved being exactly analogous to those of photometry and illumination. The formulation of point-to-point radiation in differential form, and the integration between desired limits leads in all cases to an equation of the general form

$$q = A \cdot F_A \cdot F_E \cdot \sigma(T_1^4 - T_2^4) \quad [1]$$

in which q = rate of heat transmission (B.t.u. per hr., or kg-cal. per hr.); A = area of one of the two surfaces (sq. ft. or sq. m.); σ = the Stefan-Boltzmann constant (1.723×10^{-9} B.t.u. per sq. ft. and hr., and °R⁴; or 4.9×10^{-8} kg-cal. per sq. m. and hr. and °K⁴); F_A is a factor to allow for the average angle throughout which one surface "sees" the other, and is obviously dependent on which surface is chosen to use in the area term A. F_E makes allowance for the departure of the two surfaces from complete blackness, and is a function of their individual emissivities, p_1 and p_2. Table 1 presents a summary of the various cases which have been considered, some of them from the literature on heat transmission, some adapted from problems in illumination treated in works on geometrical optics, and some not before published. All are evaluated with reference to the basic equation [1].

Limitation of space prevents our considering examples of the use of Table 1. It is applicable to a calculation of the uniformity of distribution of heat to different parts of the cold receiving surface in a furnace, to determinations of losses through openings in furnace walls, to the design of electric resistor furnaces; in short, any complete consideration of a furnace-design problem involves the evaluation of radiant heat transfer between finite surfaces.

It should be possible, with Table 1 and its accompanying graphs, to treat almost any problem which may arise. For special surfaces which do not fall under any of the above cases, however, the smaller surface may be divided into a number of equal areas, for each of which the factor F_A may be determined by the method of Case 6. The desired F_A for the whole area is then the arithmetical mean of the individual F_A's determined as above. This method involves the integral $\int d\omega \cos \Theta$, the evaluation of which Herman has treated in connection with problems in illumination.[2] Nusselt[3] has presented the same graphical method with greater clarity, but its use is attended by some difficulty, inasmuch as a three-dimensional construction is involved. For rapid solution of furnace problems of this type the author has recently constructed a simple mechanical device which has proved quick and accurate in use. Fig. 4 shows the device in two positions to indicate its mode of motion. In principle it is a right triangle ABC with the hypotenuse AC of constant length, the plane of the triangle maintained normal to the plane of the drawing board on which it is mounted, one corner A pivoted to the board, a right-angled corner B carrying a pencil, and a rod through the hypotenuse AC extensible toward E. As end E of the arm AE sweeps through space, point B traces a

[1] Professor Hottel received the degree of A.B. in Chemistry from Indiana University in 1922, and that of M.Sc. in Chemical Engineering from the Massachusetts Institute of Technology in 1924. He is now in charge of the course in fuel and gas engineering at the last-named institution.

Presented at the Second Plenary World Power Conference, Berlin, Germany, June 16–25, 1930.

[2] R. A. Herman, Treatise on Geometrical Optics, Camb. Univ. Press (1900).

[3] W. Nusselt, *Z.V.D.I.*, vol. 72 (1928), p. 673.

TABLE 1 RADIATION BETWEEN SOLIDS, FACTORS FOR USE IN EQUATION [1]

	Surfaces between which radiation is being interchanged	Area, A	Area Factor, F_A	Emissivity Factor, F_E
1	Infinite parallel planes	Either	1	$\dfrac{1}{\frac{1}{p_1}+\frac{1}{p_2}-1}$
2	Completely enclosed body, small compared to enclosing body. (Let subscripts 1 refer to enclosed body)	A_1[b]	1	p_1
3	Completely enclosed body, large compared to enclosing body. (Subscripts 1 refer to enclosed body)	A_1	1	$\dfrac{1}{\frac{1}{p_1}+\frac{1}{p_2}-1}$
4	Intermediate case between (2) and (3) above. (Incapable of exact treatment except for special shapes)	A_1	1	$p_1 > F_E > \dfrac{1}{\frac{1}{p_1}+\frac{1}{p_2}-1}$
5	Concentric spheres or infinite cylinders, special case of (4)	A_1	1	$\dfrac{1}{\frac{1}{p_1}+\frac{A_1}{A_2}\left(\frac{1}{p_2}-1\right)}$, or $\dfrac{1}{\frac{1}{p_1}+\frac{1}{p_2}-1}$[a]
6	Surface element dA and area A_2. There are various special cases of (6), with results presentable in graphical form. They follow as cases 7, 8, 9, 10...	dA	$\int \frac{d\omega \cos\Theta}{\pi}$ See text for mechanical integrator	p_1p_2
7	Element dA and rectangular surface above and parallel to it, with one corner of rectangle contained in normal to dA	dA	Given in Fig. 1	p_1p_2
8	Element dA and any rectangular surface above and parallel to it. Split rectangle into 4 having common corner above dA and treat as in case (7)	dA	Sum of 4 F_A's determined as in case (7)	p_1p_2
9	Element dA and circular disk in plane parallel to plane of dA	dA	Formula given below[c]	p_1p_2
10	Element dA and semi-infinite surface, latter generated by line moving parallel to its original position and to plane of dA. Pass plane through normal to dA, perpendicular to generating line of other surface. In this plane Θ' and Θ'' are angles made by lines connecting dA to edges of surface, with the normal to dA	dA	$\frac{\sin\Theta' - \sin\Theta''}{2}$ Only plane angles are involved	p_1p_2
11	Two parallel circular disks with centers on same normal to their planes	A_b	Formula given below[d]	Exact treatment dependent on kind of reflection, unknown. F_E lies between p_1p_2 and $\dfrac{1}{\frac{1}{p_1}+\frac{1}{p_2}-1}$ for all cases, nearer the former when areas are small compared to distance apart, nearer latter when areas are close together. Error is quite small if p_1 and p_2 are not far from unity.
12	Special case of (11), with disks of same diameter	Either	Given in Fig. 2, line (1)	
13	Two equal rectangles in parallel planes and directly opposite one another	Either	Exact formula given below[e]. Close approximation: $F_A = \sqrt{F_A' \cdot F_A''}$[f]	
14	Two equal squares in parallel planes and directly opposite one another. Special case of (13)	Either	Given in Fig. 2, line (2)	
15	Two rectangles with common side, in perpendicular planes	Either	Given in Fig. 3	Approximately, p_1p_2
16	Parallel squares or disks, connected by non-conducting but reradiating black walls	Either	Given in Fig. 2, line (3) (approximate)	Approximately, p_1p_2
17	Parallel rectangles connected by non-conducting but reradiating black walls	Either	Obtained from (16), as (13) from (14). See note[f] and Fig. 2	Approximately, p_1p_2

[a] First form results from assumption of completely diffuse reflection, second if reflection is completely specular. True value will be very much nearer first than second.

[b] Enclosed body must contain no negative curvature if A_1 is used. Replace any "dimples" in surface by equivalent planes in evaluating A_1, and raise "effective" emissivity from p_1 toward unity in proportion to depth of dimple.

[c] Case 9. R = (radius of disk)/(distance between planes); x = (distance from dA to normal through center of disk)/(distance between planes).

$$F_A = \tfrac{1}{2}\left\{1 - \frac{x^2 + 1 - R^2}{\sqrt{x^4 + 2(1 - R^2)x^2 + (1 + R^2)^2}}\right\}$$

[d] Case 11. Radii of disks = a and b. Distance between planes = K.

$$F_A = \tfrac{1}{2}\left\{1 + \frac{a^2}{b^2} + \frac{K^2}{b^2} - \sqrt{\left(1 + \frac{a^2}{b^2} + \frac{K^2}{b^2}\right)^2 - 4\frac{a^2}{b^2}}\right\}$$ Use area of disk with radius b.

curve on the drawing board. Suppose now it is desired to find the fraction F_A of the radiation from a surface element dA which is intercepted by a surface S. From cardboard a reduced model of S is cut and mounted above a point dA on a drawing board at the proper proportional distance above and to the side.[4] The pivot point A of the device is fastened into the board at the point dA, and, by moving the block B over the table, the edge of the cardboard is caused to remain barely in contact with some point along the extension rod E. When the periphery of the model has been traced, with its corresponding closed curve drawn by the pencil point, the rod ACE is dropped to draw a circle of radius AC. The ratio of the area of the first curve drawn to that of the circle is directly the factor desired, i.e., the fraction of the direct radiation from dA which is intercepted by the surface S.

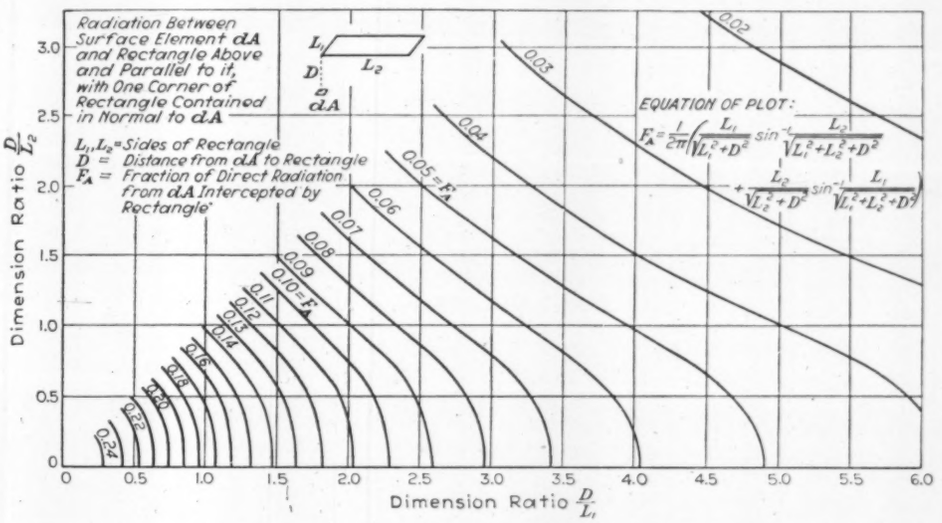


FIG. 1 RADIATION BETWEEN SURFACE ELEMENT AND RECTANGLE ABOVE AND PARALLEL TO IT

Among the special problems which may be handled by the formulas given in Table 1 is one of considerable importance in the fields of power generation and petroleum cracking, namely, the determination of the distribution of heat to several rows of tubes exposed to radiation from one side. If we consider radiation from an infinite plane to tubes of infinite extent arranged in planes parallel to the radiating plane, the problem falls under Case 10 of Table 1. The solution is presented in Fig. 5, which gives the factor F_A (based on the area of a plane replacing the tubes) as a function of the ratio of center-to-center tube distance to tube diameter. Curve (3) gives the fraction of total direct radiation from the lower plane which is intercepted directly by one row of tubes. If a non-conducting but reradiating refractory wall is placed above the tubes and allowed to come to equilibrium, the tubes now receive some reradiation from above, increasing the total F_A to that read from curve (5). If two rows are present without a refractory backing, the value of F_A is the sum of values read from curves (3) and (1). If a refractory backing is present, F_A is the sum of values read from curves (4) and (2), or curve (6). In all cases the area term in Equation [1] is that of a plane replacing the tubes. Inasmuch as the plot indicates that for most industrial cases (center-to-center distance varies between 2 and 3 times tube diameter) the radiation intercepted directly by two rows is between 87 per cent and 70 per cent of the total radiation from the lower plane, and that with a refractory backing this is increased to between 98 per cent and 91 per cent, there is little reason, from the standpoint of radiant-heat reception, for having more than two rows of tubes.

The discussion of solid radiation has so far considered chiefly the determination of the angle factor F_A, which, as has been shown, it is possible to calculate with considerable precision. The only questionable assumption in the mathematical treatment is that of the validity of Lambert's cosine principle. While this is known to lead to error, the actual emission of radiation at oblique angles being less than called for by the cosine principle, there is considerable evidence indicating that the error is small. An experimental determination of the departure of various kinds of radiating surfaces from the cosine principle is being undertaken in America by Professor Bidwell at Lehigh University.

Although an exact treatment of the emissivity factor F_E in terms of p_1 and p_2 is difficult, particularly for Cases 11 to 16 of Table 1, the limits between which F_E varies are known and are not usually far apart. The chief uncertainty in evaluating F_E arises from the incompleteness of available data on the emissivities of surfaces under different conditions. We can say in general that emissivities increase with increasing roughness, increasing thickness of oxide film if the surface is metallic, and rise

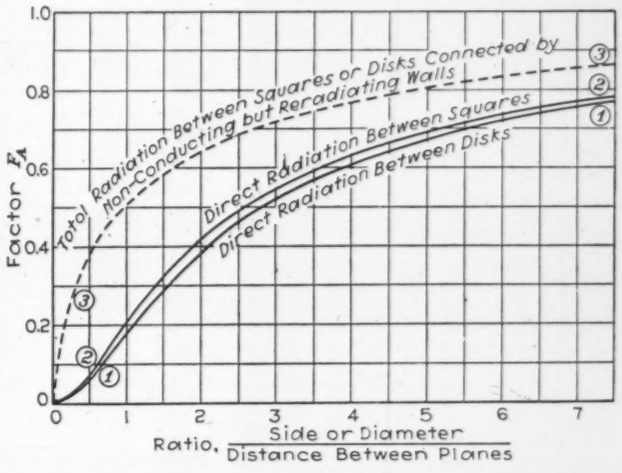

Total Radiation Between Squares or Disks Connected by Non-Conducting but Reradiating Walls
Direct Radiation Between Squares
Direct Radiation Between Disks
Factor FA
Ratio, Side or Diameter / Distance Between Planes

FIG. 2 RADIATION BETWEEN EQUAL SQUARES OR EQUAL DISKS IN PARALLEL PLANES, DIRECTLY OPPOSED

[4] Measurement is made up from the hinge point in A, not from the plane of the drawing board.

[e] Case 13. Ratios of sides to distance between planes = X and Y.

$$F_A = \frac{1}{\pi}\left\{\frac{1}{XY}\log\frac{(X^2+1)(Y^2+1)}{(X^2+Y^2+1)} - \frac{2}{Y}\tan^{-1}X - \frac{2}{X}\tan^{-1}Y + 2\sqrt{1+\frac{1}{Y^2}}\tan^{-1}\frac{X}{\sqrt{Y^2+1}} + 2\sqrt{1+\frac{1}{X^2}}\tan^{-1}\frac{Y}{\sqrt{X^2+1}}\right\}$$

[f] F_A' = factor obtained for Case 14, for squares equivalent to smaller side of rectangle. F_A'' = factor obtained for Case 14, for squares equivalent to larger side of rectangle. The approximation $F_A = \sqrt{F_A' \cdot F_A''}$ introduces less than 1 per cent error.

in temperature,[5] and that they decrease with increasing obliquity of angle of emission of radiation. The quantitative effect of such factors as the weathering of surfaces radiating at low temperatures, surface treatment, including rough and finish turning or planing, grinding, polishing, metallic spraying, galvanizing, sherardizing, tinning, calorizing, and aluminum painting, is a wide and important field for further experimental research. A fairly comprehensive summary of emissivity data is given in the new (3rd) edition of Marks' Mechanical Engineers' Handbook.[6]

Mathematical problems in the field of radiation between solids, as yet unsolved and of considerable practical importance, include the evaluation of the temperature gradient along the nonconducting but reradiating walls connecting two parallel surfaces at different but uniform temperatures,[7] the net heat interchange between two such surfaces (considered approximately in Table 1, Case 16), the transmission of heat by radiation through a mass of granular material, and the conduction of heat through a diathermanous slab with reference to the effect of point-to-point radiation and absorption coefficient.

II—Radiation From Clouds of Particles

The treatment of radiation from powdered-coal flames, from dust particles in flames, and from flames made luminous by the thermal decomposition of hydrocarbons to soot, involves the evaluation of radiation from clouds of particles.

The radiation of powdered-coal flames has been treated analytically both by Wohlenberg and his associates,[8] and by Haslam and Hottel,[9] who have shown that the radiation from the flame to its enclosing walls is expressible in the form of Equation [1] above, if we use as area that of the flame envelope, and as the "effective" emissivity of the flame envelope an expression of the form $1 - e^{-x}$. Fig. 6 gives the effective emissivity of the flame envelope for three different types of coal, each ground to two different degrees of fineness.

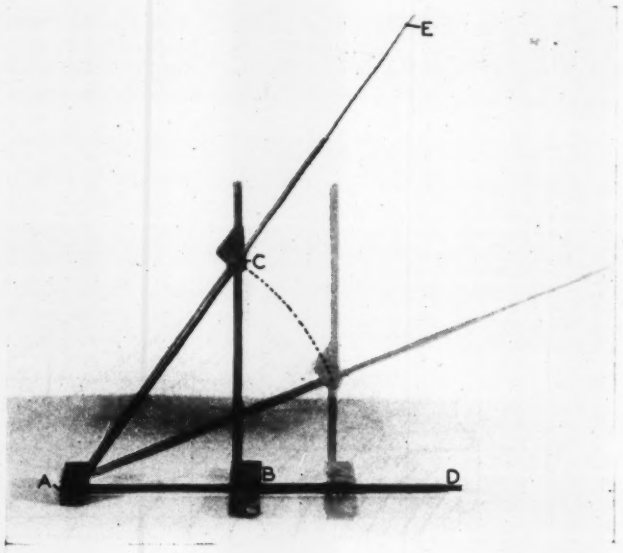


FIG. 4 MECHANICAL DEVICE FOR USE IN SOLVING PROBLEMS

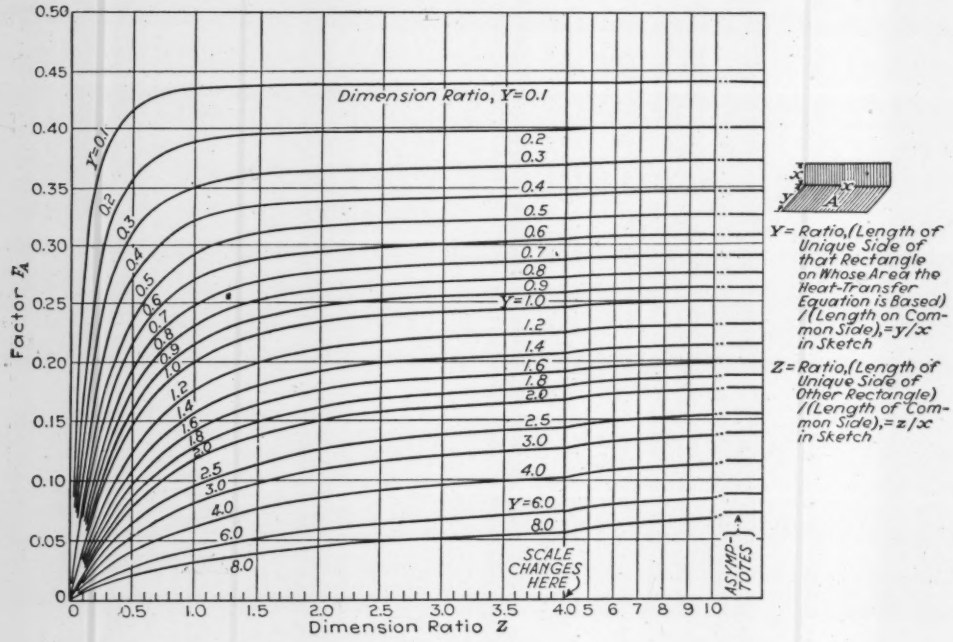


FIG. 3 RADIATION BETWEEN ADJACENT RECTANGLES IN PERPENDICULAR PLANES

The objections to the treatment resulting in Fig. 6 are that the assumptions are made of (1) constancy of surface rate of combustion of the particles in determining their average size in the flame, (2) uniformity of temperature of the flame, and (3) final particle diameter of zero instead of a diameter equivalent to that of the ash residue. These and other objections make an experimental attack of the problem of extreme importance, particularly when we consider the ever-increasing use of powdered coal in industry.

Radiation from flames made luminous by the presence of soot particles has been treated both mathematically and experimentally. Schack[10] has shown that, by measuring the true temperature of a luminous flame with a high-velocity thermocouple and its brightness temperature with an optical pyrometer, it is possible to calculate the effective emissivity of the flame envelope. Hottel has developed a two-color optical pyrometer for use with luminous flames, by means of which it is possible to calculate both the true temperature and the emissivity of the flame, having measured only its brightness temperatures at two wave lengths (red and green) with the optical pyrometer. The experimental flames used have been illuminating gas and amyl acetate flames, the thickness being varied by changing the number of flames in a straight row and sighting through their

[5] Copper, copper oxide, and the brasses are exceptions.

[6] Marks, L. S. (Editor), Mechanical Engineers' Handbook, 3rd Ed. (1930), McGraw-Hill Book Co., N. Y.

[7] The author has just completed the treatment of this problem.

[8] Wohlenberg and Morrow, Trans. A.S.M.E., vol. 47 (1925), p. 127; Wohlenberg and Lindseth, ibid., vol. 48 (1926), p. 849; Wohlenberg and Anthony, ibid. (Fuels & St. Power Sect.), vol. 51 (1929), paper FSP-51-36, p. 275.

[9] Haslam and Hottel, Trans. A.S.M.E., vol. 50 (1928), Paper FSP-50-3.

[10] Schack, A., *Zeit. f. Tech. Physik*, vol. 6 (1925), p. 530.

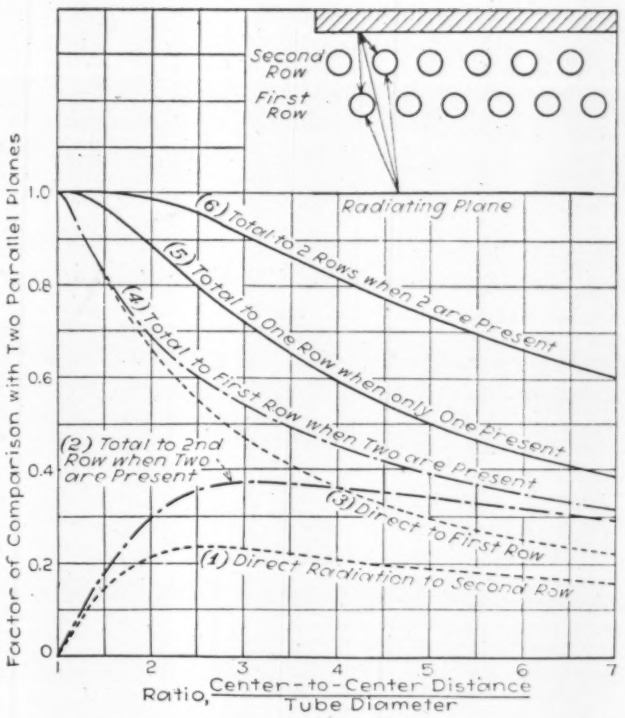

Second Row
First Row
Radiating Plane
(6) Total to 2 Rows when 2 are Present
(5) Total to One Row when only One Present
(4) Total to First Row when Two are Present
(2) Total to 2nd Row when Two are Present
(3) Direct to First Row
(1) Direct Radiation to Second Row
Factor of Comparison with Two Parallel Planes
Ratio, Center-to-Center Distance / Tube Diameter

FIG. 5 RADIATION FROM A PLANE TO ONE OR TWO ROWS OF TUBES ABOVE AND PARALLEL TO THE PLANE

(Tubes on equilateral-triangular centers; non-conducting but reradiating refractory surface above tubes. Ordinate expressed on basis of heat transferred from a plane to a plane replacing the tubes, or to an infinite number of rows of tubes.)

combined depth. Preliminary results were presented to the American Gas Association Production Conference this May.

Among the experimental determinations of radiation from luminous flames may be mentioned the work of Coblentz[11] on the acetylene flame, Gerlach[12] on the Hefner lamp, Lent[13] on the inoculation of non-luminous flames with an illuminating agent, Senftleben and Benedict[14] on the radiation and temperature of luminous flames, Haslam and Boyer[15] on measurements of total radiation from small flames of city gas, methane, ethylene, and acetylene, and Keller at Carnegie Institute on the effect of aeration and gas composition on the radiation from large gas flames. Such results (with the possible exception of the last-mentioned) are seldom applicable, however, to the design of furnaces where the shape and size of the flame, the degree of primary aeration the amount of turbulence, etc., are changed. We may generalize from the experimental results to the extent of saying that (1) radiation from luminous flames may reach very high values if the soot concentration is high, approaching within 5 per cent of that from a black body; (2) as the thickness of the flame or concentration of soot in it is increased, its visual opacity approaches unity and its apparent brightness temperature (obtained with an optical pyrometer) approaches its true temperature long before its emissivity approaches unity, thereby making ordinary visual estumation out of the question; (3) conditions favorable to cracking of hydrocarbons increase the emissivity; and (4) the heavier hydrocarbons produce more luminous flames than the lighter ones. Such factors as rate of cracking, emissivity of individual particles, amount and effect of temperature gradient, turbulence of flame, coagulation of initially formed particles into soot and subsequent diminution of size by combustion, all require experimental and analytical study.

III—RADIATION FROM CLEAR GASES

Controversy over the mechanism of origin of radiation from clear hot gases, either in non-luminous flames or in their combustion products, has been rife for more than thirty years. Although the question is not completely settled, evidence points to the view that part of the radiation can be accounted for by considering it to be due to thermal excitation of water-vapor and carbon dioxide molecules, resulting in simultaneous quantum changes in the energy levels of rotation and interatomic vibration of the molecules; that part of the radiation from flames and explosions is probably due to excitation accompanying the chemical change involved in combustion; that the first mechanism can account for the major portion of the radiation from products of combustion and from unconfined flames;[16] and that the second mechanism is controlling in the case of explosions.[17]

Schack[15] was the first to emphasize the importance of gas radiation in heat-transfer calculations on furnaces, and to indicate how the data of physicists on the infra-red absorption spectrum of gases could be used by engineers for calculating radiant heat transmission. He showed that the radiation from the envelope

[11] Coblentz, W. W., Bull. U. S. B. of Stds., vol. 9 (1913), p. 81; vol. 13 (1916), p. 357; vol. 15 (1918), p. 639.

[12] Gerlach, W., *Physik. Zeit.*, vol. 21 (1920), p. 291.

[13] Lent, *Wärme*, vol. 49 (1926), p. 145.

[14] Senftleben and Benedict, *Zeit. Tech. Physik*, vol. 7 (1926), p. 489.

[15] Haslam and Boyer, *Ind. & Eng. Chem.*, vol. 19 (1927), p. 4.

[16] Schack, A., *Zeit. f. Tech. Physik*, vol. 5 (1924), p. 267; vol. 7 (1926), p. 556; Ver. Deut. E. H. L., Mitt., no. 55, d. Warmestelle (1924).

[17] Garner and Johnson, *Phil. Mag.*, vol. 3 (1927), p. 97.

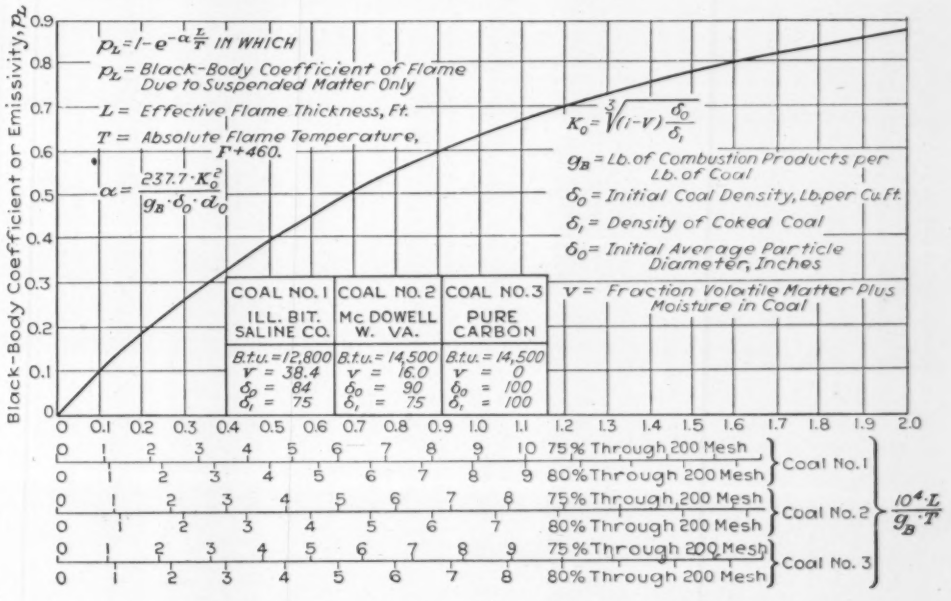

$p_L = 1 - e^{-\alpha \frac{L}{T}}$ IN WHICH
p_L = Black-Body Coefficient of Flame Due to Suspended Matter Only
L = Effective Flame Thickness, Ft.
T = Absolute Flame Temperature, °F+460.
$\alpha = \frac{237.7 \cdot K_0^2}{g_B \cdot \delta_0 \cdot d_0}$
$K_0 = \sqrt[3]{(1-V)\frac{\delta_0}{\delta_1}}$
g_B = Lb. of Combustion Products per Lb. of Coal
δ_0 = Initial Coal Density, Lb. per Cu. Ft.
δ_1 = Density of Coked Coal
d_0 = Initial Average Particle Diameter, Inches
V = Fraction Volatile Matter Plus Moisture in Coal
COAL NO. 1 ILL. BIT. SALINE CO. B.t.u. = 12,800 V = 38.4 δ_0 = 84 δ_1 = 75
COAL NO. 2 Mc DOWELL W. VA. B.t.u. = 14,500 V = 16.0 δ_0 = 90 δ_1 = 75
COAL NO. 3 PURE CARBON B.t.u. = 14,500 V = 0 δ_0 = 100 δ_1 = 100
Black-Body Coefficient or Emissivity, p_L
75% Through 200 Mesh
80% Through 200 Mesh
Coal No. 1
Coal No. 2
Coal No. 3
$\frac{10^4 \cdot L}{g_B \cdot T}$

FIG. 6 RADIATION FROM POWEDRED-COAL FLAKES

of a hot gas mass could be expressed as a complicated function of temperature, thickness of gas, partial pressure of radiating constituent, and shape of gas mass; and that, due to the localization of gas radiation in three distinct parts of the spectrum, there were three such functions to be added together to determine the total radiation due to carbon dioxide, and three more for water vapor. The results were presented in the form of tables.

Hottel,[18] following the method of Schack, showed that by proper choice of thickness of gas layer, Schack's factor to allow for gas shape could be made approximately unity for all three regions of the spectrum, thereby permitting an addition of the radiations from the different spectral regions and the expression of the total radiation from water vapor or carbon dioxide as a function of temperature, effective thickness of gas layer, and partial pressure of the gas. The results are given in the references cited in the form of graphs for quick engineering use. The problem of what value to use for mean temperature of the gas flowing along a flue or through a long furnace, when its temperature varies continuously from one end to the other, is also considered.

Objections have been raised to the method outlined in the two preceding paragraphs, chiefly on account of the failure to make allowance in the derivations for the temperature gradient which must exist in a gas layer losing heat from its bounding surface. This is a problem of considerable importance and difficulty, possibly analogous to the calculations of temperature gradients in stellar nebulae, and, to the author's knowledge, has not been attacked by any one.

A more serious objection to the data now in use for gas-radiation calculations is that they were obtained by investigators not anticipating their application to heat transfer, and that they are not as reliable as direct measurements of total radiation from gases would be. The National Research Council is sponsoring an investigation of this problem which is being carried out in the Department of Fuel and Gas Engineering of the Massachusetts Institute of Technology. It is planned to make measurements of total radiation from carbon dioxide and water vapor in varying concentrations and thicknesses of gas layer, and at different temperatures, and to follow this work by a study of radiation from unconfined flames.

The probability of occurrence, during explosions, of gas radiation other than that attributable to hot carbon dioxide and water vapor has already been mentioned. The British Gaseous Explosions Committee has obtained interesting results which have as yet not been quantitatively explained. The presence of small quantities of water vapor in carbon monoxide–oxygen explosions has a profound effect on the total radiation from such explosions.

Another problem falling under the head of radiation from clear gases is that of absorption or emission of radiation by metallic vapors above liquid metal baths. The question is of practical importance in connection with the use of total-radiation pyrometers on such surfaces, and with respect to the absorption of radiant heat in melting furnaces. Work on radiation from metallic vapors is now in progress at the University of Michigan, under the direction of Prof. H. M. Randall.

This summary of the whole field of radiant heat transmission in a paper of limited length has of necessity been sketchy. Where space has forced a choice of material for presentation, the work of American investigators has been given in somewhat greater detail than that of the Europeans because of the feeling that the former work is less generally available to the audience for which this paper is intended. The author offers his apology for any omissions in connection with statements of investigations now under way in America on the subject of heat transfer.

[18] Hottel, H. C., Trans. Am. Inst. Chem. Engrs., vol. 19 (1927); *Ind. & Eng. Chem.*, vol. 19 (1927), p. 888.

A Prophecy Fulfilled

THE late Thomas E. Murray, who was responsible for many notable improvements in large power stations in this country, offered the following prediction many years ago with respect to large-capacity boilers.

> I shall not be satisfied until I have a boiler with heat-absorption walls on all sides of the furnace. If I can accomplish this, it will result in the elimination of heavy refractory walls, which are the greatest drawbacks to continuous operation at high ratings. It will enable us to design pulverized-fuel-burning boilers with relatively small furnaces. Our present furnaces cannot withstand the punishment from the jets of burning coal, especially if we attempt to get considerable overload. We can also materially cut down the volume of the boiler house if the boiler unit can carry a high overload for a long period. This will result in lower realty and plant investment, lower maintenance charges, and, consequently, lower cost of power production. The water-wall furnace will so radically change our ideas of the design of steam-generating units that I expect we shall soon have a boiler of one million pounds' capacity per hour.

When Hell Gate Station was built it was necessary to operate the boilers at higher ratings than any station had ever been designed for, with the result that the maintenance costs, particularly in reference to refractory material of the furnace, were very high. It was to eliminate this situation that Mr. Murray suggested water cooling the furnace. The original installation of water-cooled furnaces was in connection with three 15,500-sq. ft. boilers with underfeed stokers, which made it possible to operate the boilers up to 600 per cent of rating without trouble. The only limitation was the capacity of the induced-draft-fan motor.

Somewhat later six small boilers were being installed at the Sherman Creek Station. These were to be used only for peak loads and were to be fired with fuel oil. Here Murray decided that for the economical burning of pulverized coal it would be also necessary to use water-cooled furnaces. The installation was so successful that it was decided to use pulverized fuel for the new East River Station of the New York Edison Company. The combustion at first was not satisfactory, but with changes made in the burning equipment a very high efficiency is being obtained today. At 386 per cent of rating on the boiler proper the efficiency of the boiler, superheater, and furnace was over 86 per cent on test. The experience at East River led Murray to believe that enormous capacity could be obtained from one boiler unit, which led to the design of a unit for a rating of 1,000,000 lb. per hr., with the expectation that considerable overload would be available. In the unit as actually built the rating was cut down to 800,000 lb. per hr., but recent tests on one of the boilers showed a capacity as high as 1,250,000 lb. per hr., and it is believed that even greater capacity can be obtained from these units.

There has been considerable written of late in various technical magazines regarding the desirability of having one boiler large enough for the maximum capacity of a turbine. At the present time there are in operation in the world only five turbine units requiring more steam than the capacity of one of the East River boilers. (John Lawrence, Pres., Thos. E. Murray, Inc., in *Power*, vol. 71, no. 18, May 6, 1930, pp. 710–711, 2 figs., *d*)

Survey of Engineering Progress

A Review of Attainment in Mechanical Engineering and Related Fields

AERONAUTICS

The Villiers Hydro Aeroplane With Slotted Wings

THE works of the Villiers Company are at Étang de Berre, and they are engaged in the manufacture of large hydro aeroplanes, primarily of the fleet-patrol type. A plane of that type has to be capable of operating with slow boats, but be able to get back to its base very rapidly. To make this possible the company developed the slotted wing shown in Fig. 1. The performance curves for this type of wing are given in the original article. The front-end shutters are of duralumin, some of them

FIG. 1 VILLIERS A.6 WING SECTION WITH SLOT

automatic, and others manually controlled. The latter are nearer the fuselage, and the pilot operates them by means of a flywheel acting on an irreversible system comprising an endless screw. The automatic shutters are located at the extreme end of the wing. The plane is equipped with a Gnome-Rhone Jupiter 420-hp. engine, and is said to have a cruising speed of 60 km. (roughly, 40 miles) per hr., a landing speed of 55 km. per hr., a maximum speed of 175 km. per hr., and a radius of action with the slot closed of 850 km. (*L'Aéronautique*, vol. 12, no. 131, April, 1930, pp. 137–138, *d*)

Why Does an Airplane Fly?

IN THE course of his James Forrest Lecture, Prof. R. V. Southwell called attention to the fact that it has not been yet definitely determined why an airplane flies. It used to be supposed that the lifting force developed by an airfoil advancing through the air was produced by the air pressure on the under side. About 1911, however, the National Physical Laboratory proved by measurements of the air pressure on both surfaces of an airplane wing that over half, and in some cases as much as two-thirds, of the lift was produced not by the pressure on the under side but by the vacuum on the top side. This led to an improvement in the efficiency of airplanes by calling attention to improvements possible through giving the proper shape to the top surface. Then Lanchester in England and Prandtl in Germany and some others brought about the modern theory based on a circulation of the air around the wing. This circulation hypothesis, if the fluid in which the airfoil is immersed be assumed to be inviscid, can be brought within the region of mathematical analysis and is in very good agreement with the facts of observation so far as the lift developed is considered. It is, however, completely silent as regards the drag or resistance of the wing. This resistance is not and cannot be recognized by the theory. In other words, according to the mathematicians, a wing once started in forward motion should continue indefinitely to develop lift without power being expended on it. If this mathematical theory were true it would be necessary to have a catapult to launch an airplane, but not an engine to keep it going. Mathematicians are, of course, thoroughly aware of the above, and for example, Prandtl has demonstrated by practical experiment the disagreement between the classical mathematical theory and the actual behavior of the air as it passes over and under the airfoil. This does not tell us, however, just why an airplane flies.

In his paper Professor Southwell compares the situation as it exists today with that described in 1914 by Dr. Lanchester (likewise in a James Forrest lecture). As far as the gliding angle is concerned, present-day figures show little if any advance, though as regards the gliding angle, that of the Fairey postal airplane (1 in 14.5) is a quite outstanding result. Otherwise 1 in 10 is about the flattest gliding angle of an airplane fitted with a water-cooled engine. In speed there has been substantial progress, secured partly by advance in size, in part by cleaner design, but mainly by advances in high-duty internal-combustion engines. Range is considered in detail. This part cannot be abstracted because of lack of space, which applies also to the matters of rate of climb and maximum altitude.

To summarize the review of sixteen years' achievement, the author states that safety has been attained with some approach to comfort. What mainly delays comfort is noise. Aerodynamic efficiency has been slightly improved in spite of increased speeds. Progress in this field is limited by factors which we cannot hope to evade. Range has been multiplied by more than thirteen, rate of climb by three, altitude by nearly three, speed by nearly four, and structural design has not fallen behind. The reduction in the weight of the engine has not entailed a sacrifice of reliability. In essentials, however, the airplane has not greatly changed since 1914. There have been attempts to break away from tradition, among others the tailless airplane of Capt. G. T. R. Hill, and the Autogiro of La Cierva, but none of these innovations has sufficiently established itself as yet to be properly included in this review.

The interesting discussion of the aerodynamic factors affecting safety cannot be abstracted because of lack of space. The same applies to the matter of strength of construction as affected by speed. (Prof. R. V. Southwell in his James Forrest Lecture before the Institution of Civil Engineers, May 6, 1930; published in *The Engineer*, vol. 149, no. 3878, May 9, 1930, pp. 512–514; also editorial in the same issue entitled, "Inspiration and Progress," on pp. 521–522, *gcA*)

AVIATION

The Barling Low-Wing Monoplane

THIS is a low-wing all-metal monoplane, and is of the three-place type. It is claimed to have flown from Brownsville, Tex., to Winnipeg, Canada, a distance of 1650 miles, in 16 hours, and to have consumed only 88 gal. of fuel on the trip. One of the features of this plane is the thick-section full-cantilever wing and the upturned tips, which are said to be responsible for much of its lateral stability. The main body of the wing is a single section with no division at the fuselage. It weighs, complete with ailerons, 1.15 lb. per sq. ft., and is said to have a normal load when flying fully loaded of 8.6 lb. per sq. ft. As the wing is in a

single section it cannot break off from the fuselage in the air, and in case of severe landing it intervenes between the ground and the cockpit, thus protecting the occupants. One of the features of this low-wing type is full visibility.

It is claimed that the plane never experiences a prolonged or flat spin; the pilot rarely gets this plane into a forced spin, and has never been able to hold it in a spin regardless of manipulation of controls, as it comes out of the spin automatically in $1^1/_2$ to 2 turns at most. In case of loss of air speed due to lack of power, this plane will nose over and glide until it picks up speed enough to level out. At any point in any manoeuver or any possible position in the air with power on or off, if the controls are completely released the plane will automatically right itself and resume its normal flying position. Incidentally it is the only 60-hp. plane approved by any government for three passengers. (*Canadian Aviation*, vol. 3, no. 2, Feb., 1930, pp. 14–15, 2 figs., *d*)

ENGINEERING MATERIALS (See Metallurgy: The Aluminum Alloy "Hiduminium;" and Steam Engineering: The Thickness of Boiler Tubes)

INTERNAL-COMBUSTION ENGINEERING (See also Marine Engineering: The Compounding and Supercharging of Diesel Engines)

Exhaust-Turbo Charging of a Marine Engine

A SERIES of test runs of the port engine of the twin-screw motorship *Maron* was conducted by Prof. C. J. Hawkes at the Wallsend-on-Tyne Works of the Northeastern Marine Engineering Company on January 3, 1930. The principal object of this test was to ascertain the heat flow to liners, heads, and pistons as determined by the measurement of heat carried away by the cooling media when the engine was running at various powers at constant speed.

The engine, which is of the four-cycle single-acting type, six cylinders, 24.4 in. bore by 21.2 stroke, was equipped with the Büchi system of exhaust-turbo charging and was specially designed to work on this system. The blower unit is described in the original article, as well as the details of carrying out the test. Data of the tests are given in the form of tables and curves. Because of lack of space only Table 1 (Table 6 of the original article) is given here. In connection with this table it should be noticed that owing to the large quantity of water which was passed through the jackets and coolers of the blast air compressor and the consequent small rise in temperature and the possible large errors in estimating the heat rejected to the water, the "heat to compressor" has not been included as a separate item. (*Motorship*, vol. 15, no. 5, May, 1930, pp. 317–321, illustrated, *eA*)

TABLE 1 HEAT BALANCE IN UNITS OF 100 B.T.U. PER MIN.

Trial number	1	2	3	4
Heat in fuel, higher calorific value	1970 (100)	2385 (100)	2985 (100)	3435 (100)
Thermal equivalent of b.hp.	630 (32.0)	783 (32.8)	981 (32.9)	1111 (32.3)
Heat to liners, heads, and exhaust-valve housings	326 (16.6)	407 (17.1)	472 (15.8)	562 (16.4)
Heat to pistons	63 (3.2)	77 (3.2)	101 (3.4)	104 (3.0)
Heat to compressor, exhaust gases, etc. (by diff.)	951 (48.2)	1118 (46.9)	1431 (47.9)	1658 (48.3)

High-Powered Oil Engines for Land Purposes

A REVIEW of the present situation, with particular regard to the Richardsons Westgarth engine. The chief features of this engine are as follows: Center port scavenging and exhaust is used (Fig. 3). The special feature of this arrangement is that the alternate scavenge-nozzle ports give an almost continuous scavenge-air flow without requiring special shapes of the piston top. *A* shows the normal system and *B* the supercharging system. The cylinder liner is held at the center of the scavenge exhaust belt by the upper cylinder jacket so that the ends are free to expand axially. It is therefore possible to make the scavenge exhaust belt of substantial dimensions as the outside diameter of the belt need not pass through the cylinder end. At the same time the liner ends can be kept relatively thin. The method of arranging the top and bottom nozzle ports alternately reduces the length of liner and hence the piston to the minimum possible for a given engine stroke.

Two identical fuel valves are arranged in both top and bottom cylinder covers, and the top and bottom combustion spaces are made of annulus form and almost identical. The fuel injection is on the controlled-fuel-pump system, all fuel-pump and control-

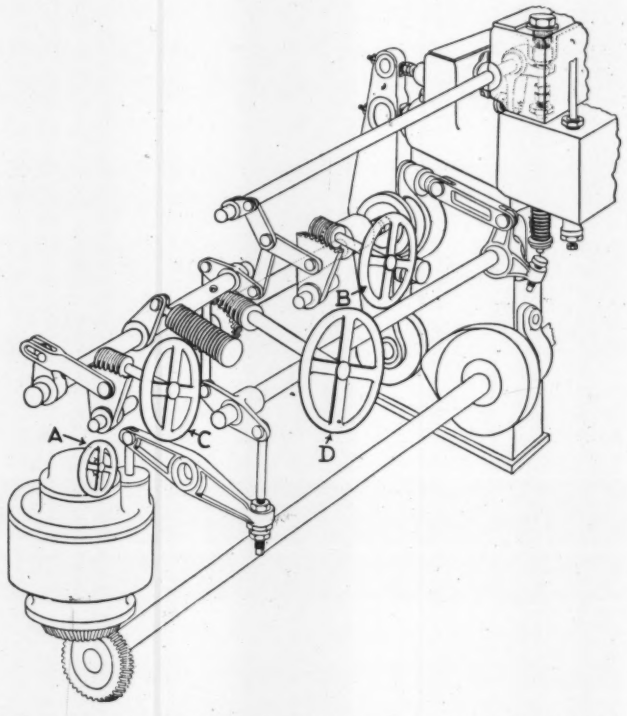


FIG. 2 DIAGRAMMATIC ASSEMBLY OF RICHARDSONS WESTGARTH OIL-ENGINE CONTROL AND GOVERNOR GEAR

gear mechanism being centralized in one unit at the control platform. The fuel valves are of a simple automatic type. The scavenge pump is of the horizontal opposed double-acting twin-cylinder uniflow type, and is said to be almost perfectly balanced in itself. This pump is gear driven from the crankshaft at a speed of from two to four times the engine speed, depending on the number of cylinders and revolutions of the main engine. The mechanically operated rotary valves of large area (separate valves for suction and discharge) are fitted to obtain high volumetric and pumping efficiencies.

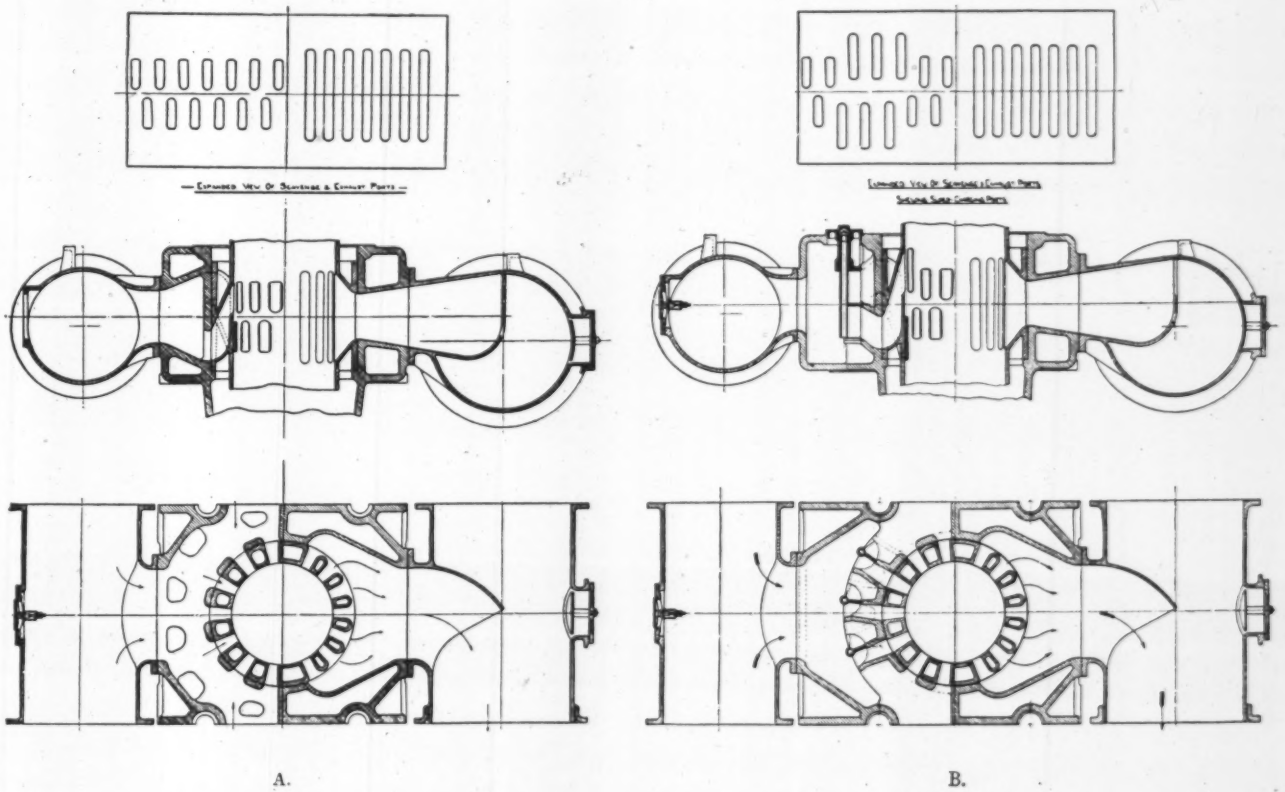
When it comes to the use of oil engines for land purposes, the oil engine has a fundamental advantage in that size has practically no effect on the fuel consumption, and it is therefore possible to employ relatively small units economically. For use in congested areas in cities the engine has the further advantage of requiring a small amount of cooling water, comparative ease in getting rid of the waste gases, and is almost completely self-contained and independent of the auxiliary machinery.

The fundamental requirement of the engines for peak-load purposes where Diesels are particularly suitable is low initial cost—which can be obtained by using higher mean pressure—and to obtain these a certain amount of supercharging can be usefully employed. This, as shown in Fig. 3(*B*), can be obtained by means of an automatic oscillating shutter device, not otherwise described in the original paper.

An interesting feature of the paper is Table II, not reproduced here, giving the unbalanced couples in the high-speed R.W. oil engine. In this connection it is pointed out that in practice the three-cylinder type has been found to be very steady.

In the slow-speed long-stroke types it is the standard practice to fit balance weights to each crank, and this no doubt has a very beneficial effect when the lesser degree of rigidity inseparable in the case of a double-acting engine are relatively small and do not warrant their inclusion, as the predominance of reciprocating weight is in the piston rod, crosshead, and guide shoe. For example, considering the three cylinder "C" type, the vertical unbalanced couple can be reduced only from 931 tons per ft. with cast-iron pistons to 869 tons per ft. with aluminum pistons, while the unbalanced secondary couple is only reduced from 119 to 105 tons per ft.

An outstanding feature of the double-acting two-stroke, particularly in the engines with five cylinders and over, is the remarkably silent and smooth running of the engine mechanically, due to the cushioning effect of the compression at each end of the stroke, and the evenness of turning moment due to the relatively large number of firing strokes from a given number of cylinders.



A. B.

FIG. 3 LEFT: SECTION THROUGH SCAVENGE EXHAUST BELT OF RICHARDSONS WESTGARTH OIL ENGINE SHOWING SYSTEM OF SCAVENGE —RIGHT: SECTION THROUGH SCAVENGE EXHAUST BELT OF THE SAME ENGINE SHOWING SYSTEM OF SUPERCHARGING

from a relatively high engine is taken into account. The short-stroke-bore ratio of the high-speed engine unfortunately prohibits the use of balance weights on the crank webs, due to the proximity of the connecting rod to the crank webs on the lower dead center.

The effect of the increased speed of revolution on the balance of engines of similar cylinder bore but of different stroke is given below:

	Residual Unbalanced Couple
8-cylinder, C.S. type, high speed, 165 r.p.m.....	1150 tons per ft.
8-cylinder, C. type, slow speed, 100 r.p.m.....	756 tons per ft.

However, the presence of balance weights on the crank webs alters the latter unbalanced couple to 398 tons per ft.—a very distinct improvement.

The effect on the balance of aluminum pistons, instead of the normal cast iron, has been investigated, but the beneficial effects

The variation in the crank effort of high-speed R.W. oil engines having different numbers of cylinders is shown in Table 3 (not reproduced here because of lack of space). The rather unusual shape of the diagrams will be of interest, particularly if compared with those obtained from slow engines in which the inertia forces are of relatively small magnitude.

It will be noticed that engines with an odd number of cylinders have a much more even crank effort than those with an even number.

The turning moment in engines having three cylinders and upward is sufficiently smooth to render special flywheels unnecessary, the inertia of the alternator being invariably sufficient to obtain the usual coefficient of fluctuation of speed of 1/250.

As regards governing, it has been the practice in the past to govern the speed of oil engines by a governor of the Hartnell or similar type which operates directly on the fuel-pump control, whether the latter is on the suction valves or on the relief or

spill valves—usually the former in air-injection engines and the latter in solid-injection engines. To give the desired sensitivity a very powerful governor and almost frictionless control gear are required. In the R.W. land-type oil engine the marine-type governor has been retained with certain modifications. Instead of controlling the suction valves by the hand regulator or the governor to obtain regulation of the speed and power, the relief valves are controlled only for reasons of timing. The governing is effected by dual control of the relief or spill valves, together with a simultaneous but lesser control of the suction valves. An efficient automatic control of the timing of the fuel injection can therefore be obtained at all loads. By means of a hand regulator it is possible to regulate the relative amount of control effected on the suction or relief shafts on which are mounted bell cranks operating the valves.

Instead of the governor operating these shafts direct, however, a powerful hydraulic-relay action has been incorporated with the governor on lines very similar to that appertaining to steam-turbine practice. The governor therefore only acts in its proper capacity as a "brain," while the necessary "muscle" is in the form of the simple but powerful relay cylinder. It will be appreciated that this gives a much greater scope in designing a substantial, quiet, and efficient control gear, and one which can give the sensitive control required for paralleling.

The R.W. control and governor gear is shown diagrammatically in Fig. 2. Operation of the wheel *A* controls the relay-cylinder oil pressure and the engine speed; wheel *B* is a hand control by which can be selected—while the engine is running—the portion of the cam profile best suited to give good combustion with the various fuels and conditions met with in service. By means of wheel *C* the engine can be hand regulated from "stop" to "full load." The large wheel *D* operates the main starting air gear. It is essential that engines for peak-load work or engines which run intermittently should be capable of ready and simple starting. Nothing is more objectionable than a Diesel engine which lifts relief valves on starting and requires acrobatic qualities in the engineer, which are sometimes necessary when the starting and fuel-control gear are not situated all together on the control platform. For this reason the starting gear in the R.W. land-type engine is practically identical to that used most successfully in the marine type, where good starting and maneuvering capabilities are of prime importance, and the physical effort required small. Similarly, all controls are centralized at the control station, together with all pressure gages, exhaust-gas thermometers, illuminated water outlets—with regulators and thermometers, counter, tachometer, illuminated cylinder lubricators, etc.

Although a relatively low compression is utilized (350 lb. per sq. in.) this has been found to be quite adequate even in the coldest weather for making a start without preheating of the jacket water, although the latter is sometimes considered preferable as being more kindly to the cylinder when starting up, and facilitating a perfectly clean exhaust from the moment of putting on to "fuel."

In an appendix the author gives comparative layouts of steam- and oil-engine plants for an output of 20,000 kw. The designs are drawn to the same scale, and a list of parts of auxiliaries required for both systems is given. The difference in size is quite striking. (W. S. Burn in *Diesel Engine Users' Association*, S 93, meeting of January 31, 1930, original paper 28 pp. with inserts and discussion pp. 29–40, *d*)

MACHINE PARTS (See Special Machinery: A Tube-Straightening Machine With Cross-Roll Drive Through Spiral Gears)

MACHINE TOOLS

The Hydraulic Operation of Machine Tools

IN DISCUSSING the application of hydraulic power to the operation of machine tools the editorial here abstracted gives some little-known history of this development, from which it would appear that the first application (in England) of hydraulic operation to lathes was made during the war by Littlejohn Philip at the works of Spencer & Co., Ltd., Melksham.

In the Philip lathes the saddles and tool slides were all operated hydraulically. The lathes were immensely powerful, the noses of 9-in. shells being "formed" at one operation by tools with a total cutting edge about 18 in. long. Their ease of manipulation was as striking as their capacity for work, and the unbreakableness conferred by the impossibility of the designed pressure on the tool being exceeded, was abundantly displayed. Indeed, if the resistance to the motion of the saddle became unduly great, as it might do if, when making a roughing cut, the diameter of the work became excessive or if a hard patch of metal was encountered or if the edge of the tool failed, all that happened was that the speed of traverse became automatically less, the pressure on the tool remaining constant. For lathe work of a heavy nature, therefore, the possibilities of the hydraulic drive have been demonstrated as adequately as they have in the case of essentially reciprocating machines.

Littlejohn Philip, by the way, was not a machine-tool builder by profession, and the building of lathes at his works was discontinued at the termination of the war. (*Engineer*, vol. 149, no. 3877, May 2, 1930, pp. 491–492, *gh*)

MANAGEMENT

Management Methods in the Richman Bros. Co., Cleveland, Ohio

IT IS CLAIMED that not more than two weeks pass from the time raw materials are purchased until the moment they are sold in retail stores owned by this company, which makes medium-priced men's suits. This was accomplished not by the use of special machinery nor, as the original article expresses it, by long conveyor lines or by devising automatic machinery into which a bolt of goods is fed to emerge at the other end as coats, vests, and trousers. The results achieved are credited by the writer, a vice-president of the company, to certain forms of organization and also to the fact that 90 per cent of the work people in the company own stock.

To understand the situation it should be noted that the Richman Company is selling through its own retail stores and therefore does not have to consider the ideas of retailers. It determines the styles of the garments and makes them all of a given design, varying only in sizes. This is therefore the nearest approach to such mass manufacturing as is maintained, for example, in the average automobile plant. Certain of the methods used are worth notice. Thus, for instance, a few years ago the management did away with time clocks. It was taking the employees 20 min. to ring in in the morning and ring out at night. The time records had to be checked and handled through the timekeeping department. The management put it up to the employees to be so prompt that the lack of time clocks would not be felt. The experiment proved to be a complete success.

A still more unusual method is used in the matter of piece rates and records. Operators are allowed to keep their own piece-work records. These records they turn in at the end of each day and are paid on their own records. The only auditing is done by an auditing committee which samples the records of the operators in one department each week and checks them back to ascertain their accuracy. In ten years under this plan there

were found only two persons who were cheating, and inaccuracies are so unusual and so minor that it would cost much more to audit all the production records than to pay on them without question.

In the clothing industry a standard sewing department consists of twenty machines with operators and from four to six non-working supervisors. In the Richman Company there are two supervisors in each department of twenty, and these supervisors work on actual production operations themselves. The supervisor is responsible for quality, quantity of output being allowed to take care of itself. As practically all the employees work on piece rate and the flow of work is rapid, it is unnecessary to drive them. The company stresses quality, and lets the employees drive themselves on production.

The piece rates are not excessively high and are said to yield the employee just a fair going rate for the class of work, but full-time employment is given in an industry where it is notoriously seasonal. For many years the plant has worked 49 weeks a year and has given 52 weeks pay for this work, the difference being a week's vacation in the summer and a winter holiday extending from the day before Christmas until the day after New Year. (F. C. Lewman, Vice-Pres. and Gen. Mgr., The Richman Bros. Co., Cleveland, Ohio, in *Factory and Industrial Management*, vol. 79, no. 6, June, 1920, pp. 1337–1339, 4 figs., *d*)

MARINE ENGINEERING (See also Internal-Combustion Engineering: Exhaust-Turbo Charging of a Marine Engine)

Armor and the Washington Cruiser

THE author, a Dutch engineer, gives an analysis of the design of a cruiser that would satisfy the 10,000-ton limitations of the Washington agreement and would represent the highest possible fighting qualities. The design was developed with the help of Dutch naval officers. As a basis of this design it was assumed that the cruiser should have a speed that would permit it to outrun, and hence to decline action with, any capital ship with the exception of the British battle cruisers *Hood*, *Renown*, and *Repulse*. This reasoning indicates that the ship should be provided with armor to keep out 8-in. shells at a reasonable range—assumed to be 10,000 m. (10,940 yd.). This would give 5.9 in. of vertical armor on the water line and the barbettes, and 2 in. for horizontal armor on the armor deck, with 7.9 in. for the conning towers and front plates of gun houses. No torpedo armament has been included in the design. A speed of 30 knots in the full-load condition was specified. The gun equipment was to consist of six 8-in. guns placed in two triple turrets and a considerable amount of anti-aircraft equipment.

The secondary and lighter guns are quite scattered. The guns are therefore placed so as to take care of their double function of heavy anti-aircraft and anti-destroyer guns. Four out of six are placed between the single funnel and the second mast, and a sufficient distance from the ship's side to permit their being used against flying targets on the opposite side of the vessel as soon as elevation becomes high enough to prevent serious gun blast upon the guns on the other side. The middle pair of these weapons are mounted upon elevator platforms to permit flying in a fore-and-aft line.

The two known pitfalls in powering long, high-speed vessels are cavitation and frictional resistance, which latter would seem to be underestimated from Froude's time-honored method. Serious interference from the former seems to be eliminated by designing the ship for the cavitation limit, while it was attempted to evade the latter difficulty by making use of Kemp's formula for frictional resistance. For the form ultimately adopted, with L. W. L. = 588 ft. 11 in., N = 64 ft. 11½ in., and d = 21 ft. 4 in., the resistance was thereby computed as follows:

Residuary resistance from Taylor's standard series	22,700 e.hp.
Friction resistance from Froude's formula	18,050
"Usual" bare hull resistance	40,750
Extra frictional resistance under Kempf's formula	4,610
Corrected bare hull resistance	43,360
Appendage resistance as given by Dyson, 12 per cent	5,440
Supposed real tow-rope resistance	50,800 e.hp.

To find the propulsive efficiency, a number of propeller forms and revolutions were investigated by means of Schaffran's standard series in combination with Luke's data for wake and thrust deduction. In order to make the propeller area as large as possible, four propellers were chosen. For these, Luke's results are with outward-running screws as follows:

	Forward screws	After screws
Wake	22 per cent	18 per cent
Thrust deduction	13 per cent	13 per cent
Hull efficiency	1.06	1.01

These data have been obtained for lower speeds, but had to be used in the present case in the absence of further information. The propeller diameters were taken as large as possible, i.e., at 11 ft. 11½ in. according to the writer on warship design in *Werft-Reederei-Hafen*. With a pitch of about 14 ft. 6 in. and a projected-area ratio of 0.75, 75,000 s.hp. at 250 r.p.m. would yield the 50,800 e.hp. required. The projected-area ratio was taken from Dyson's book, as being the limit at which interference between the individual blades begins to impair the efficiency of the screw. The unit mean pressure on the projected area is then limited to 13¼ lb. per sq. in. for the forward propellers and to 13 lb. per sq. in. for the after ones, as against Barnaby's limit of 13 to 14 lb. per sq. in. The tip speed at 250 revolutions would be 9300 ft. per min. as against Taylor's limit of 9000 ft. per min. Thus it may be hoped that the influence of cavitation may remain inconsiderable.

That there is a real foundation for such a hope may be made clear by a comparison with the performance of the British cruisers already mentioned, and from the theoretical aspect by the fact that, although the propulsive coefficient when taken as the quotient of the supposed real tow-rope horsepower over the shaft horsepower is as high as 67.7 per cent, this coefficient when taken in the usual way (bare-hull hp. over s.hp.) is as low as 54.4 per cent, or quite in line with what is now known of the results of long, high-speed ships when cavitation is not too serious. A small reserve of power may even be present. (G. H. Hoffman in *The Shipbuilder*, vol. 37, no. 239, May, 1930, pp. 490–493, 2 figs., *d*)

High-Pressure Steam on Board Ship

A BENSON marine boiler with preheated air for generating 10 tons of steam per hour is shown in Fig. 4. In its lower port are two large combustion chambers, the walls of which are formed by coiled piping consisting of five sets of concentric pipes. In the upper part are situated the preheating and superheating systems, which can be readily removed with their supports. The ends of the coils are connected to headers. All the pipes have an outer diameter of 33 mm. (1.37 in.) and an inner diameter of 20 mm. (0.78 in.). Other illustrations in the original article show a small Schmidt marine boiler built as a two-stage pressure boiler and a Löffler marine boiler which is able to generate 25 tons of steam per hour.

As regards the general construction of high-pressure marine boilers, special care must be applied to the water circulation, feedwater, combustion chambers, and intermediate superheaters. Narrow water tubes have been found to insure a much better water circulation than wide ones. They must be arranged vertically, or at least considerably inclined, and the difference in height between their upper and lower ends must be as large as possible. All designs in which local superheating may occur in the turbines. In the combustion chambers of boilers which contain only a small quantity of water, it is of importance that the fire should be easily regulated. This is best done by oil or by pulverized-coal firing. Pulverized-coal firing is best employed in a boiler in which the heat is mostly transmitted by radiation.

Thermal efficiency is greatly improved by intermediate superheating. For marine plants intermediate superheating by fresh steam requires superheaters of so large a surface that they have

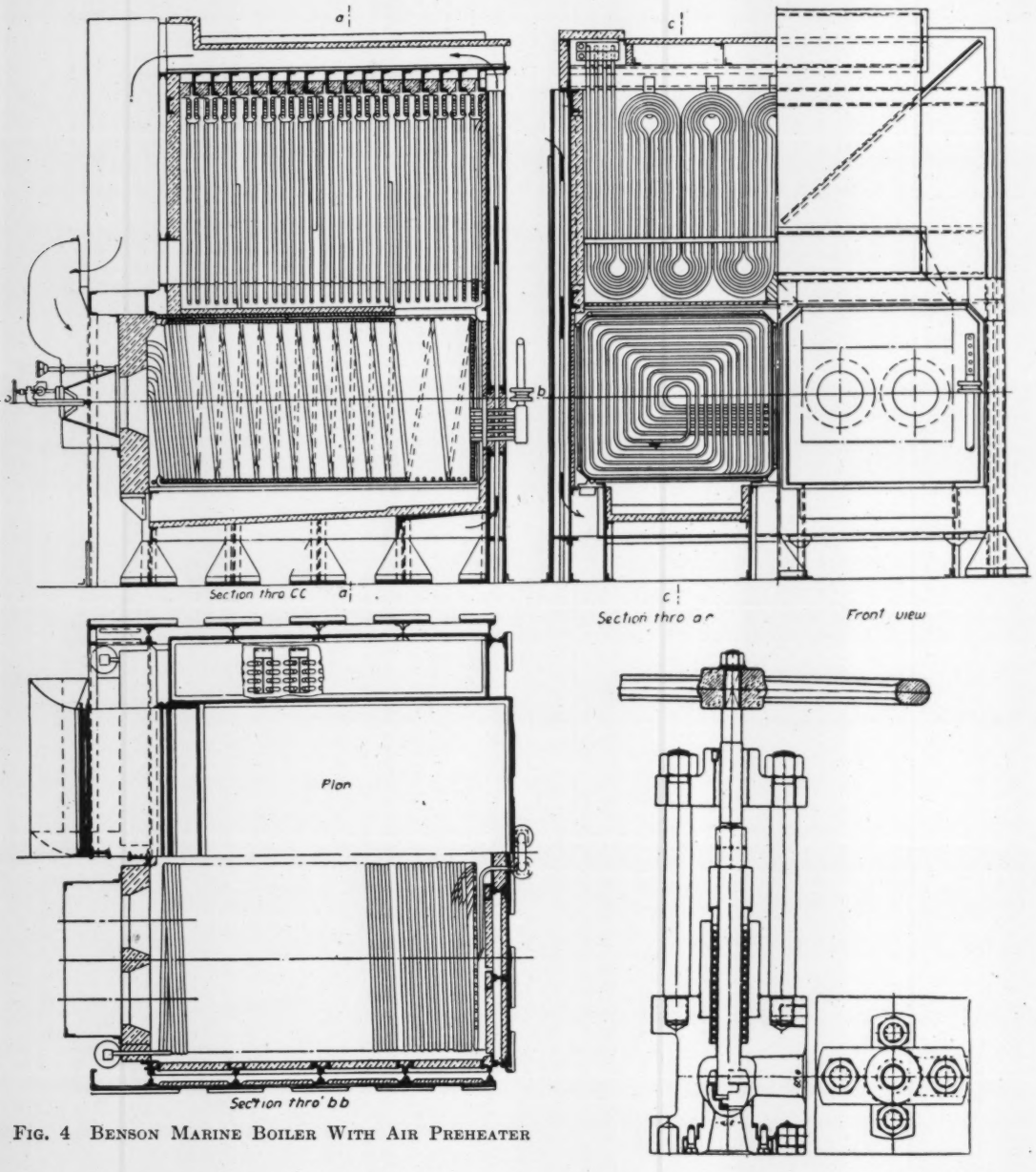


FIG. 4 BENSON MARINE BOILER WITH AIR PREHEATER

must be avoided, as at a steam temperature up to 900 deg. fahr. and above, the temperature of the tubes must not be allowed to rise much beyond that of the steam. The feedwater must be as pure as possible. Preheating the feedwater to a high temperature is of great advantage in this respect, as by it the impurities are separated in the form of mud. A good speed of circulation of the water also produces a small amount of sediment, and the water must be as free as possible from air. Experience with superpressure boilers shows that the steam also must be kept as free as possible from impurities in order to prevent a sediment not been applied until recently. With superpressure plants the system will be applied under more favorable practical conditions.

During recent years it has been possible to develop all the details and piping of superpressure boilers to the utmost of their reliability. For instance, all parts of a large Löffler boiler have stood extended tests with excellent results. An evaporation of up to 400 cu. ft. of water per hr. per sq. ft. of water surface was obtained in their boiler. All the pipes of the Löffler boiler are welded wherever possible. Flange connections are made without any packing material, and they have proved to be absolutely

tight. The valve for a Benson boiler for the passage of 30 tons of steam per hour has a diameter of 60 mm. (2.36 in.), while for a corresponding valve for steam of 200 lb. pressure, 210 mm. (8.26 in.) diameter would be required. This comparison shows the possibilties of weight saving due to the smaller dimensions used with superpressure steam.

The original article shows also a superpressure Schmidt-Borsig reciprocating steam engine. It has five cylinders on four cranks. The high-pressure cylinder and the first medium-pressure cylinder are single-acting and work in tandem above each other, an arrangement by which the troublesome high-pressure stuffing box is avoided. The other cylinders are double-acting. A similar engine is said to have just been delivered to America and is working with steam at 1440 lb. per sq. in. pressure and a temperature of 800 deg. fahr. It works against a back pressure of 60 lb. per sq. in., and the waste heat is used in a turbine.

For marine purposes, where the saving of weight is of importance, it would be an advantage to expand the high-pressure steam of plants of small and medium size (up to 5000 hp.) in double-expansion reciprocating engines from 1860 lb. per sq. in. down to about 185 per sq. in., and then after intermediate superheating, to the condenser pressure in turbines. In larger plants a similar high efficiency may be obtained by using high-pressure turbines without reciprocating engines. The space and weight requirements of such high-pressure engines are much smaller than those of normal steam plants. In addition, the boilers are small and light. A 7000-b.hp. marine steam-turbine plant with Löffler boilers of 1860 lb. per sq. in. pressure has a weight of 1000 tons, while the weight of a 200-lb. per sq. in. pressure turbine plant with cylindrical boilers is 1350 tons, and that of a corresponding double-acting Diesel engine, 1600 tons. If an oil-fuel price of 48 marks ($11.50) per ton and a coal price of 20 marks ($4.75) per ton are made the basis of comparison, the daily fuel costs of the plant amounts to 1330 marks ($316) for the high-pressure plant with pulverized-coal firing, and to 3120 marks ($742) for the medium-pressure plant with oil firing. (Chief Engr. Graeber at the Power and Fuel Meeting, Bremen, Sept., 1929; abstracted through *The Shipbuilder*, vol. 37, no. 238, April, 1930, pp. 408–411, 7 figs., *dA*)

The Compounding and Supercharging of Diesel Engines

AS REGARDS compounding, the author considers first the use of a gas turbine to recover the energy contained in the exhaust gases. He calculates the power recovered by the turbine and shows that the effective power recovered increases steadily with the back pressure. For example, the percentage recovery is 10 per cent with a back pressure of 1 kg., and only 4.5 per cent with a back pressure of 0.5 kg. As the turbine element must be run at a high rate of revolution, the utilization of power recovered presents a difficulty. It may, however, be usefully employed in connection with supercharging, the turbine being used as a blower.

If the ratio (weight of fuel/weight of air) is maintained constant, the final temperature will not be increased. But the increase in the amount of fuel and air supplied to the cylinder will result in an increase of power and of maximum pressure. Increase of maximum pressure will result in increased stresses in the material of the cylinder. With the assumption that combustion occurs at constant pressure, this may be obviated by reducing the compression ratio. Tests on the M.A.N. engine referred to have shown that with a compression ratio of 26, instead of the normal figure 36, the engine operates satisfactorily, a maximum pressure of 38.5 kg. being obtained with 300 hp. at a speed of 450 r.p.m. Further experiments have shown that the difference between maximum pressure and pressure at the end of the compression diminishes rapidly as the latter is increased. In other words, the combustion approximates more and more closely to constant-pressure conditions. It follows that, with a compression ratio of 26 and a supercharging pressure of 1.5 kg. absolute, the final pressure of compression is 39 kg. The pressure at the end of combustion is a little over 40 kg., and under these conditions the engine will develop about 1.5 times its normal power.

It is presupposed that the supercharging air is supplied to the engine at the normal temperature of the surrounding air, and some form of cooler must be introduced between the compressor and the engine to effect this.

It may be stated that, with air supercharging at a pressure of 1.5 kg. a power a little more than 50 per cent above normal may be developed, the final temperature of combustion remaining the same, but being attained a little later. The temperature and pressure of the exhaust are somewhat increased. For the M.A.N. engine referred to, the increase in maximum temperature attained under supercharged conditions was less than 8 per cent, while the period of combustion was increased by about one-fourth of its normal value, and the temperature at the commencement of exhaust was about 20 per cent in excess of normal.

Supercharging may be effected by means of an independent compressor or by means of a turbo-compressor utilizing the exhaust gases, and the author shows that the latter is preferable. With a supercharging pressure of 1.5 kg. the effective powers developed, after deducting the power absorbed by an independent compressor and allowing for the loss due to back pressure in the case of an exhaust turbine, are as follows: With an independent compressor of efficiency 0.7, 406 hp.; with an exhaust turbo-compressor of efficiency 0.4, 434 hp.; and with an exhaust turbo-compressor of efficiency 0.6, 448 hp.

An important consideration arises in connection with the efficiency of the turbo-blower. If this is low, the compressor will only supply supercharging air at a pressure practically equal to that of the exhaust, and as a result scavenging will not be possible. Calculations indicate that the pressure of the supercharging is practically equal to that of the exhaust, when the efficiency of the turbo compressor is 0.36. The excess of the supercharging pressure over that of the exhaust increases with increase of supercharging pressure and efficiency, the excess being greater than 100 grams with a supercharging pressure of 1.350 kg. and an efficiency of 0.45. Scavenging in such a case will therefore be easily realized.

The author refers to elaborate experiments on a M.A.N. 300-hp. engine. These were carried on with a compression ratio adjusted to 26, and it was found that the power was increased by supercharging from 55 to 107 per cent. The maximum indicated pressure is somewhat increased by supercharging. At 450 r.p.m. the increase was from 42 kg. to 44.5 kg., equivalent to about 5 per cent increase; the thermal efficiency is of about the same order as in the normal engine, and so is the specific fuel consumption. The original article gives the leading characteristics of a four-stroke-cycle supercharging engine which

TABLE 2

Item	Four-stroke cycle, normal	Four-stroke cycle, supercharged	Two-stroke cycle, normal
Maximum space required:			
Longitudinal	12.840 m.	9.720 m.	12.800 m.
Transverse	1.700 m.	2.000 m.	1.800 m.
Approximate weight	75 tons	75 tons	85 tons
Specific consumption	195 gr.	192 gr.	220 gr.

the author designed for the *Redoubtable* class of submarines. The design would have a mechanical efficiency of 0.82 and an efficiency of turbo-compressor of 0.5. Table 2 (III of the original article) gives a comparison between the supercharged

engine and normal engines of both two- and four-stroke-cycle types developing the same horsepower. (M. Gauthier, of the Association Technique Maritime et Aeronautique, in a paper abstracted through *The Shipbuilder*, vol. 37, no. 238, April, 1930, pp. 432–433, *ce*)

METALLURGY

The Musso Steel Process

THIS is one of the direct processes of reducing iron ore. A plant to make steel by this process is being erected at Ottawa, Canada. Ore is reduced to spongy iron by coal at low temperatures, and the gas produced from this coal together with the carbon monoxide resulting from the union of carbon and the oxygen of the ore provides all the heat necessary for the reduction in the retort. It is claimed that the total coal required is only 40 per cent of that required in blast-furnace and open-hearth methods, and that this coal may be of any ordinary quality.

Iron ore and fuel finely ground and properly mixed are introduced into a rotary retort. The gases are rapidly removed from the retort, and, as stated above, constitute the fuel to heat it and operate the plant. The original article describes in a general way the reactions taking place, and also gives a flow diagram.

The Mines Branch of the Department of Mines, at Ottawa, is investigating the subject of direct reduction of iron ores, and have made preparations to undertake a complete study of Canadian ores which are not suitable for economical blast-furnace operation. An arrangement has been made by the Musso Steel Process, Limited, of Canada, with the Mines Branch for a commercial demonstration of the Musso process. A pilot plant, with a capacity of about 4 tons of steel ingots per day, is now under construction in Ottawa by the company, and steel will be produced in the near future. This plant will be similar in all essential features, except size, to a standard Musso unit of 100 tons ingot capacity per day, and all the operating data for a larger plant will be accurately determined. Large plants will consist of a group of standard 100-ton units. (C. E. Parsons, Resident Engr., Musso Steel Process, Ltd., of Canada, in *Iron and Steel of Canada*, vol. 13, no. 4, Apr., 1930, pp. 73–74 and 93–95, *d*)

The Aluminum Alloy "Hiduminium"

THIS is an alloy developed at the Rolls Royce Laboratory at Derby, England, and now used for all light-alloy castings by that company in cars and aero engines. The composition of the alloy is as follows:

	Per Cent
Copper	0.5 to 5.0
Nickel	0.2 to 1.5
Magnesium	0.1 to 5.0
Iron	0.6 to 1.5
Titanium	Up to 0.5
Silicon	0.2 to 5.0
Aluminum	Remainder

For the various applications the elements are divided into four grades: (1) for sand and die castings for general purposes; (2) for die castings for pistons; (3) for forgings for general purposes; and (4) for forgings suitable for high-quality pistons. All grades of the material are capable of being strengthened by heat treatment. The forgings have a high-temperature heat treatment, and after quenching, are subjected to an aging process; the castings are subjected to low-temperature treatment. The temperature for the treatment of the castings is not higher than 175 deg. cent., so that distortion or cracking during quenching is obviated.

The casting and forging of this material is easier than for any other known aluminum alloy, but the machining calls for some little extra care. The minimum figures to be expected in this alloy are given in the original article.

It has been found unnecessary to use chills. The material is very fluid, and high temperatures for casting thin sections can be adopted without detriment.

The pattern should be studied, and ample provision should be made for getting large runners and risers well distributed. It is desirable to get the metal into the mold as quickly as possible, and to have sufficient material in the runners and risers to continue feeding the casting while shrinkage is taking place. One need not be afraid that the runners and risers, owing to their size, will cause draws. Chills should not be considered as a means of overcoming draws, unless the place to be chilled is in some isolated part of the casting and cannot be fed. The temperature of pouring for the average casting is from 700 to 720 deg. cent., but for extremely thin sections higher temperatures can safely be adopted. An increase of temperature overcomes the tendency to draw in a portion of the casting.

The majority of castings in this material can safely be left in the molds for a considerable period, and it has not been found necessary, even in the case of the most delicate castings, to break out the core sand until the castings are practically cold. This is an obvious advantage in production.

In the majority of cases heat treatment is not necessary, but for particularly highly stressed parts the treatment necessary is to heat the casting to 175 deg. cent., holding it there at least 16 hr., and quenching in water. All casting can be carried out safely in green-sand molds. (W. C. Devereux, Managing Director of High Duty Alloys, Ltd., in a paper before the British Institution of Production Engineers; abstracted through *Automotive Industries*, vol. 62, no. 18, May 3, 1930, pp. 697–698, *d*)

NATIONAL DEFENSE (See Marine Engineering: Armor and the Washington Cruiser)

PETROLEUM

A New Principle in Oil-Well Pumping

THIS method is described as the "atomizing" method. The oil is elevated from its fluid level through tubing by a combination of mechanical atomization and hydrostatic load relief, and is said to be the invention of Ralph H. Tucker. The operation of reciprocating plunger pumps with sucker rods necessitates the lifting of the fluid against the hydrostatic load. In the Tucker method a device is used which is known as the Continental turbine air-lift pump. The principle of pumping oil by this equipment involves the application of a minimum pressure of either air or gas, after the kick-off, into an enclosed area within the bottom of the tubing and its introduction into the pumping element through angled port holes. This pressure is allowed to pass through tangential port holes and exerts its force upon a motor which operates not unlike a steam turbine. The motor within the pump is equipped with a continuous series of 41 angular faces or vanes. An impeller or screw integral with the motor rotates, picking up the oil from the reservoir. The air or gas leaving the motor through port holes strikes the oil column at the top end of the pump and causes complete atomization, thoroughly mixing the gas or air with the oil. By using a restricted size of tubing to the top of the pump, the gas or air cannot slip. The oil rides along with the gas by means of

atomization and is brought to the surface and delivered into tanks where the gas or air separates from the oil, leaving the latter as solid liquid. A big advantage in the use of gas in this way is said to be the remarkable increase in the gravity of the oil. It is believed that this pump will operate at any depth in

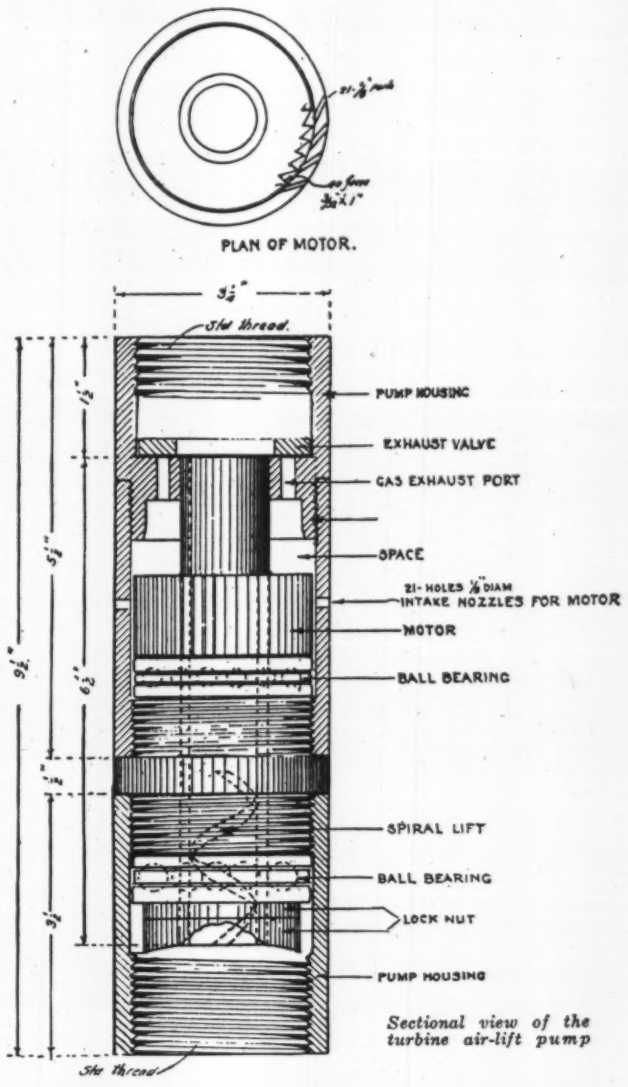


FIG. 5 SECTIONAL VIEW OF TURBINE AIR-LIFT OIL-WELL PUMP

any type of well, and it is especially desirable in crooked holes where sucker rods cannot be conveniently used. A sectional view of the pump is shown in Fig. 5. The ball bearings are used only as a guide and have practically no thrust imposed upon them. Sand does not harm the bearings, because of the powerful blower action of the gas or air. (L. E. McCune in *Oil Field Engineering*, vol. 7, no. 3, March, 1930, pp. 42–43, 2 figs., *d*)

POWER-PLANT ENGINEERING

Operating Characteristics of Turbine Governors

ON SEVERAL occasions the system of Duquesne Light Company of Pittsburgh has developed periods of severe surging. During these surges indications have been that one or more generators were out of synchronism for periods of time lasting from a few seconds to several minutes. The system has two major power stations located approximately 18 miles apart—the Colfax and the Brunot Island stations. The governors at the Brunot Island station are of the flyball type with a single oil relay actuating the primary valve mechanism. Due to a large number of 11-kv. fixtures and bus reactions preventing a major loss of load, faults on a section near Brunot Island do not cause severe overspeeding. The governors at the Colfax power station are of a recent type and consist of the flyball mechanism and an oil relay which in turn actuates a larger oil relay giving the force to the mechanism of the primary valve. To insure an adequate supply of oil at constant pressure during the period when the primary valve relays were operating, oil accumulators were added to the governor oil system. The new system of governing reduces the load on the flyball governor when tending to correct the valve setting. The reduction of duty on flyballs has resulted in a much faster and more accurate following of the speed changes, allowing the governors to hold the turbines below the limit of the auto-stop setting.

The purpose of the tests described in this paper was to determine the effect of the governors during observed periods of surging. Colfax has ten generators ranging from 23,600 kva. to 48,500 kva., grouped in four units. Units Nos. 1 and 2 each consist of a high-pressure turbine, exhausting to two low-pressure turbines, each having a generator of 23,600 kva. connected to it. The high-pressure turbine governor normally controls the load for the entire unit. Units Nos. 3 and 4 each have two single-shaft turbo-generators of 35,300 and 48,500 kva., respectively, unit No. 4 having the oil-relay type of governor.

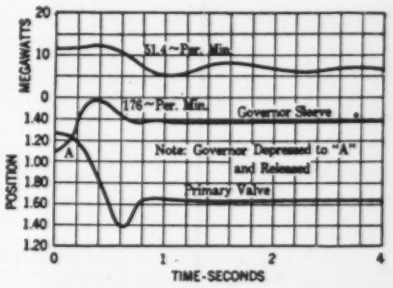


FIG. 6 GOVERNOR-PERIOD TEST

Brunot Island has seven generators, five single-shaft turbo-generators with a capacity of 18,000 kva. each, and one cross-compound of 47,200 kva. capacity. Each element of the compound unit is rated at 23,600 kva.

The results of these tests indicated that on units Nos. 1 and 2 the governor period varied from 100 to 135 cycles per min. and the load-swing period from 80 to 87.8 cycles per min. Units Nos. 3 and 4 indicated an average period of 143 cycles per min. for the governor oscillation and 62.2 cycles per min. for the load swing. The discrepancy between the period of the load swing for units Nos. 1 and 2 and Nos. 3 and 4 can be accounted for by the difference in moments of inertia of the revolving masses. The moments of inertia of 1-B and 2-B are 220,800 lb-ft.², 3-A and 3-B have a moment of inertia of 560,000 lb-ft.², and 4-A and 4-B have moments of inertia of 586,000 lb-ft.²

The ratio of the governor period of oscillation to the load oscillation for Nos. 1 and 2 is 1.45 to 1. For Nos. 3 and 4 the ratio is 2.3 to 1. In order that one system may support an oscillation in another system, the two must be in resonance; that is, having the same period. Also, the two oscillations must have a phase displacement of 180 deg. If the natural period of the governor is the same as the natural period of the rotor, and the time lag between the governor action and the effect of the steam on the rotor equals one-half of this period, this condition can be met on the turbine. If it is assumed that the governors oscillate at their natural period, the effect on the turbine due to the variation in steam flow would not tend to sustain oscillation of the generator output, due to the difference in

frequency between the governor and rotor periods. Also, the tests indicate that the governor mechanism comes to its position of equilibrium after an impulse within one and a half cycles of governor oscillation.

The second series of tests was undertaken to check the natural period of the complete system. It was not possible to create sufficient disturbance to oscillate the system, but the tests did indicate that the generator output closely follows the steam input from low frequency until the variation in the primary valve movement reaches a period of from 60 to 70 cycles per min. Above this frequency the amplitude of the swing decreases, until at approximately 100 cycles per min. the steam variation becomes too fast to affect the output. It would appear, therefore, that if the governors did oscillate their period would be too fast to have any appreciable effect on a load swing.

A third series of tests indicates that the governors are sensitive enough to hold the turbine from overspeeding, and tend to check the speed of the turbine during the pole slip. (T. E. Purcell and A. P. Hayward, both of the Duquesne Light Co., Pittsburgh, Pa., in a paper published in abridged form in the *Journal of the American Institute of Electrical Engineers*, vol. 49, no. 5, May, 1930, pp. 366–369, including bibliography, *e*)

RAILROAD ENGINEERING

New Types of Locomotives

THIS is an abstract of a report submitted by R. E. L. Maunsell, Chief Mechanical Engineer, Southern Railway (Great Britain), to the 11th Section of the International Railway Congress Association, Madrid, May 5–15, 1930, and covers turbine locomotives and steam reciprocating engines which are not directly connected to the coupled wheels, internal-combustion locomotives, and locomotives having boilers of special design.

In the case of turbine locomotives the London, Midland, and Scottish Railway reports the trial of an experimental Ljungström turbine locomotive built by Beyer, Peacock & Co., Ltd. This locomotive was intended for normal express service. No data as to performance are given, except that it is said that on a trial run with a 40-ton passenger train a drawbar horsepower of 1200 was recorded and the highest speed required was 76 m.p.h. With 500-ton trains the coal consumption averaged 0.11 lb. per ton-mile, excluding engines, and the water consumption was about 4 gal. per mile. No figures are available for cost of repairs and maintenance. The London and Northeastern Railway, England, contemplates putting into service a Diesel-electric locomotive, a brief description of which is as follows:

This experimental locomotive is being prepared by the conversion of one of the existing electric locomotives of the Newport and Shildon electrified line. These are eight-wheeled, double-truck engines, and electric motors drive each of the four axles independently of one another. The power unit to be installed consisted of a Beardmore variable-speed Diesel engine of 1000 b.hp. coupled to an 800-volt d.c. generator, separately excited by an auxiliary generator. This supplies current to the four d.c. series traction motors, which are geared to the axles in the ratio of 1 to 4.5. The motors are permanently connected in parallel and are force-ventilated.

A driving position is located at each end of the locomotive, and the control is all-electric. This acts upon the governor of the Diesel engine and on the field of the generator. Reversing is accomplished through the reverse handle of the master controller operating a drum-type reverser, which connects the traction-motor armatures and their fields in the opposite direction. The locomotive weighs 90 tons, all of which is available for adhesion. The maximum starting effort is 40,000 lb., approximately 18 tons. The continuous rating is 775 hp. at rail at 27 m.p.h. The engine will be used in heavy main-line freight and ore traffic at present worked by 2–8–0-type steam locomotives. (*The Railway Gazette*, vol. 52, no. 16, Apr. 18, 1930, pp. 596 and 601, *g*. See also Journal of the International Railway Congress Association, English edition, vol. 12, no. 4, Apr., 1930, pp. 1259–1305, 8 figs., and Mar., 1930, pp. 863–950, 21 figs.)

REFRIGERATION

Organic Fluorides as Refrigerants

THOMAS MIDGLEY, JR., and Albert L. Henne have discovered that individual members of a certain class of organic compounds may be selected for use as refrigerants having any desired combination of engineering properties along with lack of toxicity and lack of inflammability. This class is described as the fluoro-halo derivatives of aliphatic hydrocarbons. It has been found further that when fluorine replaces hydrogen on a carbon atom which is already linked to one or more halogen atoms in an organic compound containing halogen, there is a material lowering of the boiling point. Furthermore while substitution of halogen for hydrogen in general increases toxicity, it is rather surprising that the substitution of fluorine for hydrogen on a carbon atom reduces toxicity in spite of the toxic properties of inorganic fluorides.

An analysis of the possible compounds led to the selection of dichloro-difluoromethane ($C Cl_2F_2$) which has a boiling point of —30 deg. cent. and a freezing point of —155 deg. cent. Its vapor is stable for at least thirty days at 175 deg. cent. if pure and dry and in an unreactive container. Its corrosion characteristics are satisfactory with high- and low-carbon and stainless steels, aluminum, copper, monel metal, tin, and tin-lead solders, doubtful with phosphor bronze and Everdur bronze, and unsatisfactory with brasses and magnesium alloys. Water causes corrosion and decomposition. Extensive tests were made to establish the non-toxicity of the material. It is intended to use the material as a refrigerant in place of such materials as ammonia. (Thomas Midgley, Jr., and Albert L. Henne, Frigidaire Corp., Dayton, Ohio, in *Industrial and Engineering Chemistry*, vol. 22, no. 5, May, 1930, pp. 542–545, 3 figs., *d*)

SPECIAL MACHINERY (See also Steam Engineering: Governor Gear for a High-Speed Reciprocating Steam Engine; and Petroleum: A New Principle in Oil-Well Pumping)

A Tube-Straightening Machine With Cross-Roll Drive Through Spiral Gears

THE Treadwell Engineering Co., of Easton, Pa., has built under the patents of B. B. Abramsen a tube-straightening machine said to be the largest machine of that kind in the world and to have a capacity for straightening both seamless and welded tubing in diameters of $^1/_8$ in. to 30 in. and round bars in diameters of $^1/_8$ in. to 6 in.

The rolls are positively driven through spiral gears, no intervening idlers being employed. This method of drive results in constant contact of the rolls with the work, thus maintaining even and smooth roll surfaces and lengthening their life. It also prevents any tendency toward the formation of ridges or other imperfections in the product being straightened. The absence of idlers in the drive, it is claimed, eliminates flat spots and actual crushing of the tube. Another of the novel features incorporated in the design is the absence of guides, either above or below the work. Straightening and rounding of tubes is obtained with only the rolls in contact with the work.

Built upon shoes are three sets of housings which carry three

pairs of cross-rolls. The housings are provided with adjustments both lengthwise and crosswise so that the bending moment of the material being straightened may be increased or decreased as desired. The driving unit is an electric motor which, through bevel gears, drives horizontal shafts on which the spiral driving gears are mounted. All gears are of alloy steel, fully enclosed and run in oil. The machine is foolproof as to adjustment; it can be adjusted by any laborer, and, when set, maintains its adjustment indefinitely. A feature of the roll units is that they are interchangeable, so that users of these machines need carry but one set of spare parts.

The speed of the machine varies in accordance with the size of stock being straightened. It ranges from 450 ft. per min. on small bars to 150 ft. per min. on large diameters. (*Iron Trade Review*, vol. 86, no. 22, May 29, 1930, p. 56, 1 fig., *d*)

The Photoelectric Cell

TO PUT the photoelectric cell, or as it is sometimes called, "the electric eye," to work the engineer must give his apparatus "intelligence" to analyze or interpret what it sees. For example, in one application the photo cell is trained upon packages in order to cause those to be thrown aside where the label is missing.

There are a number of types of photoelectric cells. Those which are used for grading or matching colors usually require a suitable color filter in connection with the light source so that the percentage change in cell response may be a maximum following a change in color. Among other things, the article, of which only the first part has been published, describes the method of amplification used in connection with photoelectric cells, in particular the use of the grid glow tube. (Serial article by J. V. Breisky, of the Westinghouse Elec. & Mfg. Co., in *Electronics*, vol. 1, no. 2, May, 1930, pp. 74–76, 7 figs., *dp*)

Magnetic Track Brakes

MAGNETIC track brakes have been tried from time to time both in this country and in Europe (Glasgow). As a rule they did not prove satisfactory. It is therefore all the more interesting to see that the Kentucky Traction and Terminal Company operating the city service and interurban lines in several places around Lexington, Ky., has found their experience with this type so favorable that interurban freight motor cars are now being equipped with this brake.

It is claimed that the use of magnetic track brakes in combination with air brakes has resulted in a marked reduction in accidents. For example, the average number of accidents in the 1924–25 period of straight air operation on the interurban lines was 80 as compared with 62 as an average for the period 1927–28 with air-magnetic brakes, a reduction of 22.5 per cent. This improvement has continued through 1929. An even more striking comparison is found in the cost of accident claims, which were reduced 59.6 per cent. This record was made in the face of an increase of 4.1 per cent in speed and 28.6 per cent increase in automobile registration for the territory, and a 15.8 per cent increase in miles operated.

An even better comparison is shown in the combined city operations. The average number of accidents for the 1924–25 period of straight air operation was 284 compared with 247 for the 1927–28 air-magnetic period, a reduction of 13 per cent. Although the percentage in reduction in number of accidents was not so great as on the interurban lines, the cost of accident claims was reduced 75 per cent on the city lines. This remarkable record was achieved with an increase of 9.8 per cent in the speed, an increase of 28.6 per cent in automobile registration, and 29.4 per cent in miles operated.

It is claimed that the total maintenance cost increased 67 cents per 1000 car-miles in 1928 where magnetic brakes were used, as compared with 1926 when straight air brakes were used. There was, however, an important saving through reduction in cost of accidents, etc., as well as through a reduction in the number of brakeshoes used and fewer flywheels. There were two failures of magnetic brakes in 1927, and only one in 1928. The yearly maintenance cost for 53 magnetic brakes was $632.31, and only $170.39 of this amount is represented by material, the being charged to labor. (E. M. Carr, Supt. of Equipme entucky Traction and Terminal Co. in *Electric Traction*, 26, no. 4, Apr., 1930, pp. 191–192, 2 figs., *d*)

STEAM ENGINEERING

The Thickness of Boiler Tubes

TWO conflicting considerations govern the determination of the thickness of boiler tubes. The tube must be thick enough to withstand the pressure stresses for a reasonably long life in spite of corrosion. On the other hand, temperature stresses in the tube increase rapidly as the thickness is increased. In modern boilers these temperature stresses are important, and, especially in the fire-row tubes, are often much greater than the pressure stresses.

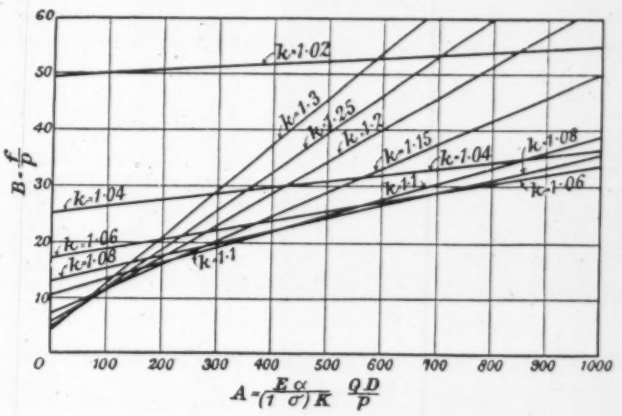


FIG. 7 VALUES OF RATIO (EQUIVALENT STRESS/PRESSURE IN TUBE)

In this paper the author deduces the "equivalent" or "resultant" stress in tubes of any given thickness under any given conditions of heat flow and pressure, and then proposes means of determining the tube thickness which gives the minimum equivalent stress under these conditions. The thickness thus selected must be increased to take care of corrosion. The author analyzes the stresses in a tube. He points out that in fire-row tubes high stresses exist, and produces evidence to prove it. He also notes that it is only under modern conditions of large heat flow that the question of tube thickness becomes important.

Fig. 7 gives values of the ratio (equivalent stress/pressure in tube), represented by the symbol B, on a base proportional to the ratio (heat flow/pressure), represented by the symbol A, for tubes of various thicknesses. Actually, the ratio

$$A = \frac{E\alpha}{(1-\sigma)K} \times \frac{Q \times D}{p}$$

where E = Young's modulus of material of tube
α = coefficient of linear expansion with temperature
σ = Poisson's ratio
K = heat conductivity
Q = heat flow per unit time per unit area of outside surface of tube
D = outside diameter of tube, and
p = pressure inside tube.

This can be calculated or deduced from a nomogram in the original article. Two scales are given on the heat-flow line, one for use when $\frac{E\alpha}{(1-\sigma)K} \times Q \times D$ has been worked out, and the other, for steel tubes only, in the use of which only $Q \times D$ need be evaluated. In this latter case, Q must be the B.t.u. per square foot per minute, and D in inches. The following values of E, α, σ, and K have been assumed:

$E = 30 \times 10^6$ lb. per sq. in. $\quad \alpha = 11 \times 10^{-6}$ per deg. cent.

$\sigma = 0.3$; $\quad K = 6.16 \times 10^{-4} \frac{\text{T.U.C.}}{\text{deg. cent. inch sec.}}$

The quantity $\frac{E\alpha}{(1-\sigma)K} \times Q \times D$ is of the nature of a stress, and is evaluated in lb. per sq. in. The third line of the nomogram gives p in lb. per sq. in., and the second line the value of the ratio A.

The tube thickness is expressed by the ratio k = external diameter ÷ internal diameter. A nomogram in the original article gives the relation between k and the actual thickness for any given diameter, viz.,

$$t = \frac{k-1}{2k} D.$$

In an appendix the author shows the derivation of the formula for temperature and pressure stresses in thick tubes. This cannot be abstracted because of lack of space. He derives the following formula for equivalent stress:

$$B^2 = \alpha \times A^2 + \beta \times B + \gamma$$

In this equation α, β, and γ are expressed in terms of hoop, radial, and axial stresses. From this equation Fig. 7 on the preceding page has been deduced by the author. (James Gray Docherty in *Engineering*, vol. 129, no. 3354, Apr. 25, 1930, pp. 527–529, 9 figs., *t*)

Governor Gear for a High-Speed Reciprocating Steam Engine

THIS article describes a high-speed steam engine made by W. Sisson & Co., Ltd., of Gloucester, England. The engine is a compound one and has two cylinders so arranged that the two crankshafts can be brought very close together, with a resultant decrease in the consequent dynamic couple and the load on the main journals. This is claimed to increase steadiness in running. One of the most interesting parts of this engine is the governor (Fig. 8).

The governor is partly embodied in the eccentric. The operation is such that the sheave center of the eccentric is altered relatively to the center of the shaft when variations of load occur. The path of this center in moving with increasing angular advance from the full-load position X to the no-load position O is curved, and toward the no-load position the linear advance, and therefore the lead, is rapidly reduced, so that at the extreme no-load position the high-pressure valve gives no steam opening. The movement is effected by the centrifugal action of a weight A, which is forked and hinges to a bracket forged solid with the end-crankshaft web, the forked ends being bushed. The eccentric sheave is connected to an extension of one of the forks by the pin C, and is also coupled to the shaft by the link D and the pin E. The sheave, which is practically a simple ring standing well clear of the crankshaft, is thus carried upon two points, from one of which, viz., C, its angular movement is derived, the other, E, being merely a suspensory point which swings in an arc upon any movement of C. Movement is given to C by the lever weight A acting upon its fulcrum B. The weight is controlled by spring gear F, the rod of which is coupled to the forks by the pin G. This spring gear is arranged radially to avoid distortion at high speeds, and the rod passes right through the crankshaft.

The regulation of both valves simultaneously by the governor enables the receiver pressure to be maintained to a practically uniform degree at all loads, and in consequence, both with load

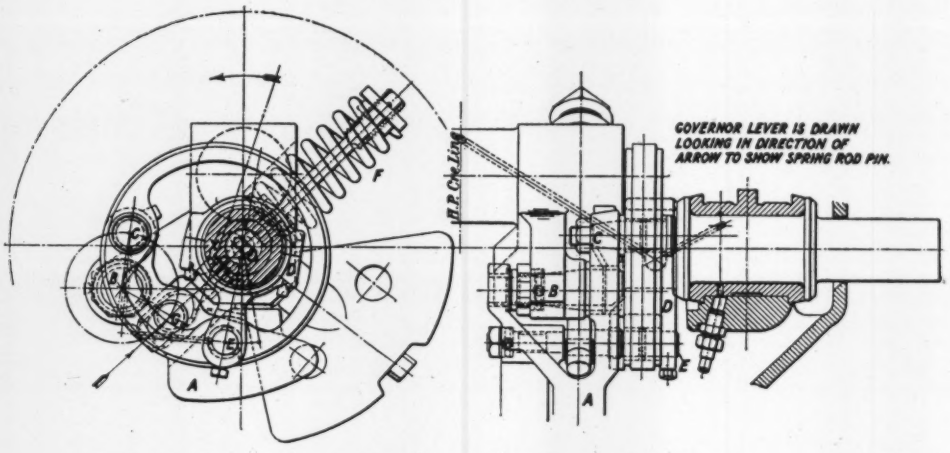


FIG. 8 GOVERNOR FOR SISSON HIGH-SPEED STEAM ENGINE

thrown off and with load throw on, a smaller momentary change of speed is secured. In the first case, with load thrown off, the steam which has passed the high-pressure cylinder is retained in the receiver, and with load thrown on the maintenance of speed is not dependent only on the prompt action of the governor in giving extended admission to the high-pressure cylinder, but also on the low-pressure cylinder's being supplied from the steam retained in the receiver. In addition to the good governing control of the system adopted, it is claimed that there is a distinct thermal advantage conducive to economy due to the automatic superheating of the steam by compression at the lower loads. This is well shown by a comparison of the Willans line for a throttle-governed engine with the corresponding Sankey curve for an expansion-governed engine without alteration of compression, and with the Sankey curve of the Sisson engine governed by expansion and compression in both the high-pressure and low-pressure cylinders. The Sankey curve of total water in an engine with unaltered compression is concave throughout, but that of the Sisson engine is modified by the curve below half-load, changing into a flat waved curve, the mean of which is approximately parallel to the Willans line. (*Engineering*, vol. 129, no. 3355, May 2, 1930, pp. 570–571, 6 figs., *d*)

CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society.

Engineering and Industrial Standardization

Standardization of Iron and Steel Bars

ON JUNE 3 the Sectional Committee on the Standardization of Stock Sizes, Shapes, and Lengths for Hot- and Cold-Finished Iron and Steel Bars held its organization meeting in New York. Cloyd M. Chapman, past-chairman of the A.S.M.E. Standardization Committee, acted as chairman to open the meeting, and Dr. P. G. Agnew, secretary of the American Standards Association, made a few introductory remarks.

At this meeting F. H. Frankland, manager of technical service of the American In titute of Steel Construction, Inc., was elected temporary chairman. The scope of the committee was thoroughly discussed, and as a result the organization of three subcommittees was authorized on, (1) hot-rolled steel, (2) cold-finished steels, and (3) hot-rolled iron. The members of the Committee were of the opinion that for the present these subcommittees will be able to handle the scope of its work, which has been tentatively outlined as the standardization of the dimensions of cross-section and length of hot-rolled and cold-finished iron and steel bars having the following shapes: (1) rounds, (2) squares, (3) triangular sections, (4) hexagons, (5) octagons, (6) half-rounds, (7) square-edge flats, (8) nut-steel flats, (9) beveled-corner squares, and (10) round-cornered squares; including tolerances on the dimensions of such bars. Nationally recognized standards are to be accepted where possible. It was also agreed to include half-ovals and reinforcing bars in this tentative scope.

Meeting on Steel Pipe Flanges and Flanged Fittings

IN NEW YORK on April 18, Subcommittee No. 3 on Steel Pipe Flanges and Flanged Fittings, with Chairman C. P. Bliss presiding, met to discuss the reports submitted by the various subgroups. Besides the Subcommittee members, several members of the Sectional Committee on Pipe Flanges and Flanged Fittings, as well as a number of guests, attended the meeting.

The question of increasing the pressure ratings of the existing 250-, 400-, and 1350-lb. steel standards to 300-, 450-, and 1500-lb., respectively, at 750 deg. fahr. was taken up, together with the possibility of extending these standards to include equipment for 150 lb. as the lower limit, and for the latter it was suggested that the dimensions of the present 125-lb. cast-iron standard be used, but in conjunction with reduced temperature ratings. During the discussion on the 200- and 400-lb. standards it developed that in some sizes the flange and wall thicknesses would have to be increased or, as an alternative to this, alloy steel with a higher yield point might be used and the existing dimensions retained. On this point action was deferred until it could be ascertained how the increase in wall and flange thicknesses would affect the present patterns of steel valves and fittings. In connection with the rerating of the 1350-lb. standard it was decided that, for sizes of 12 in. and under, it should be rerated at 1500 lb. and 750 deg. fahr., employing alloy steel in accordance with specifications to be drawn up by the A.S.T.M.; also that a new subgroup be appointed to continue this study and to complete the work already started on the larger sizes from 14 to 24 in. in the 1500-lb. class.

Steel base fittings were discussed, and inasmuch as it was reported that the M.S.S.V.F.I. has already adopted a standard for these, which accurately represented accepted practice, it was voted that this be included in the proposed revision of the American Steel Flanged Fitting Standard.

The difference existing between the present 250-lb. cast-steel and cast-iron standards in the matter of flange thickness for certain sizes was mentioned, as was the possibility of extending the steel standard to cover sizes below 2 in., but it was deemed advisable, for the present at least, to take no action in connection with either of these points.

At a previous meeting, the Subcommittee decided to eliminate the $3^1/_2$-in. size from all Pipe Flanges and Flanged Fitting Standards, but as it was reported that the M.S.S.V.F.I. were proceeding with a canvass of the manufacturers in order to ascertain the practicability of this step, the Subcommittee decided to reconsider its former decision and delay any action until such a time as a further report might be available.

Considerable interest has been shown in standards for pressure ratings higher than 1500 lb. and in response to this, it was stated, two preliminary standards had been drafted for 2500 lb. and 3500 lb. at 1000 deg. fahr. These were based on the expectations that an alloy steel with a working stress of not less than 14,000 lb. would be developed. As the demand for data on such equipment was increasing more rapidly than had been anticipated, a committee of two, with the privilege of adding to its personnel as might be found necessary, was appointed.

Based on replies to a questionnaire sent to a selected list of 536 engineers, on their expressed opinion it was recommended that no changes in the thicknesses as covered by the Tentative American Standard for Steel Pipe Flanges and Flanged Fittings, be considered at the present time. It was, however, recommended that the recently developed dimensions for optimum hubs be checked and prepared for submission to the Subcommittee.

American Railway Association Contributing to A.S.A.

BY A RECENT action of the Board of Directors of the American Railway Association, it was unanimously agreed to subscribe a total of $45,000 toward the work of the American Standards Association.

Representatives of the various divisions of the American Railway Association have for some time held membership on the sectional committees of the American Standards Association which have developed American standards for unification of screw threads, pipe flanges and fittings, bolt, nut, and rivet proportions, scientific and engineering symbols and abbreviations, and the national electric safety code.

In addition to having representation on the committees having completed standards, they are participating in numerous others, including those for wire and sheet-metal gages, dimensions and material of wrought-iron and wrought-steel pipe and tubing, wire and cables, power-line insulators, machine pins, specifications for zinc coating of iron and steel, drawings and drafting-room practice, and rails and splice bars.

They are also interested in the development of safety codes for walkway surfaces, protection against lightning, protection of the head and eyes of industrial workers, industrial sanitation, and conveyors and conveying machinery.

Track Bolts and Nuts

THIS proposed American Standard for Track Bolts and Nuts is one of the many projects within the scope of the Sectional Committee on the Standardization of Bolt, Nut, and Rivet Proportions. This Committee was organized in accordance with the procedure of the American Standards Association by the Society of Automotive Engineers and The American Society of Mechanical Engineers as joint sponsors. It now consists of 56 members representing 18 organizations, and is fully representative of the manufacturer, user, and general interests.

The Subcommittee on Track Bolts was organized in February, 1922. With the cooperation of the Rail Committee of the Engineering Division of the American Railway Association, an exhaustive study of the various types of track bolts previously manufactured was made and two series of bolt-head dimensions developed. Proof copies of this proposed standard were widely distributed for criticism and comment in May, 1926. The suggestions received in reply to this circularization have been experimentally investigated, and the results are embodied in the present revision.

The accompanying tables show the designs of oval-neck track bolts selected, as well as three types of nuts, and it is felt that these, together with the elliptic-neck track bolts in the range of sizes covered by this Proposed Standard, should adequately meet the requirements of both consumer and producer.

The Subcommittee will, however, be pleased to receive comment or criticism on the data as set forth, and those who desire to make a more detailed review on the subject may obtain a copy of the complete report by addressing C. B. LePage, Assistant Secretary, A.S.M.E., 29 West 39th Street, New York, N. Y.

Oval Neck Track Bolts

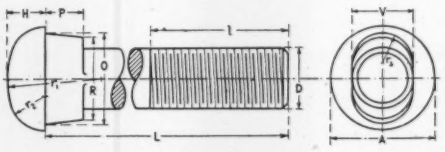


Table No. 1 Oval Neck Track Bolts

D	A	H	r_1	r_2	O	R	P	r_3	V	E	K	L	l	Threads Per Inch
Nominal Diameter Over Thread	Head				Neck					Bearing[1] Area Sq. In.	Shearing[2] Area Sq. In.	Length Under Head	Minimum Thread Length	
½	⅞	5/16	11/16	9/32	⅝	19/32	5/16	½ body diameter of bolt	Same as body diameter of bolt	0.317	0.45	From 3 to 6 inches by Steps of ¼ inch From 6 to 10 inches by steps of ½ inch	1 ½	13
5/8	1 5/64	25/64	59/64	23/64	13/16	25/32	3/8			0.458	0.71		1 ¾	11
¾	1 9/32	15/32	1 5/32	7/16	1 1/16	1 3/32	7/16			0.567	1.07		1 ¾	10
⅞	1 37/64	35/64	1 21/64	13/32	1 5/32	1 7/16	½			0.796	1.64		2	9
1	1 11/16	5/8	1 5/8	15/32	1 17/32	1 11/32	9/16			1.018	1.86		2 ¼	8
1 ⅛	1 57/64	45/64	1 53/64	43/64	1 11/16	1 ½	5/8			1.294	2.33		2 ½	7
1 ¼	2 3/32	25/32	2 3/32	¾		1 21/32	11/16			1.600	2.86		2 ½	7
Special Sizes, For use During Transition Period														
[1] 7/16	25/32	9/32	37/64	⅛	35/64	33/64	9/32	½ body diameter of bolt	Same as body diameter of bolt	0.227	0.35	Length as Specified	1 1/16	14
9/16	63/64	23/64	13/16	21/64	45/64	43/64	11/32			0.364	0.58		1 3/16	12
11/16	1 3/64	7/16	1 3/64	13/32	53/64	51/64	13/32			0.532	0.88		1 5/8	11
13/16	1 25/64	25/64	1 7/32	37/64	1 9/64	1 7/64	15/32			0.734	1.23		1 7/8	10
15/16	1 19/32	19/32	1 33/64	9/16	1 13/64	1 17/64	17/32			0.968	1.63		2 1/8	9
1-1/16	1 81/64	43/64	1 ¾	41/64	1 29/64	1 27/64	19/32			1.191	2.12		2 3/8	8

All dimensions are given in inches, unless otherwise noted.

Screw Threads: The screw threads on track bolts shall conform to the American National Standard form with fit as specified or have the Harvey Grip thread. They may be formed by cutting, drawing or rolling.

[1] Note: Bearing area is equal to the area of bolt head minus the area of the oval hole in the splice bar.

[2] Note: Shear area is equal to the periphery of the oval hole in the splice bar times the mean height of the head above the bearing surface.

Tolerances: Length (L) plus or minus 1/4 inch.
Neck (V, O and R) plus or minus 1/32 inch
Head (A and H) plus or minus 1/16 inch.

Formulas

$A = 1\frac{5}{8}D + \frac{1}{16}$
$H = \frac{5}{8}D$
$r = 1\frac{7}{8}D - \frac{1}{4}$
$r = H - \frac{1}{16}$
$O = (1\frac{1}{4}D$ (For 7/16 to 3/8 inch Incl.)
$O = 1\frac{1}{4}D + \frac{1}{16}$ (For 1 1/16 to 1 1/4 inch Incl.)
$R = O - \frac{1}{16}$
$P = \frac{1}{2}D + \frac{1}{16}$

Track Bolt Nuts

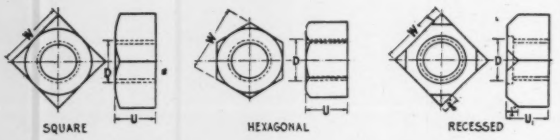


Table No. 3 Square and Hexagonal Nuts For Track Bolts

Diameter of Bolt D	WIDTH ACROSS FLATS[1] (W)		THICKNESS[2] (U)			THICKNESS[2] (U_1)					
	Maximum	Minimum	Common[4]			Extra Thick			Recessed		
			Nominal	Maximum	Minimum	Nominal	Maximum	Minimum	Nominal	Maximum	Minimum
½ 0.5000	13/16 0.8125	0.788	7/16	0.458	0.418	11/16	0.708	0.668	11/16	0.708	0.668
5/8 0.6250	1 1.0000	0.969	35/64	0.569	0.525	51/64	0.819	0.775	51/64	0.819	0.775
¾ 0.7500	1 1/8 1.1250	1.088	21/32	0.680	0.632	29/32	0.930	0.882	29/32	0.930	0.882
⅞ 0.8750	1 5/16 1.3125	1.269	49/64	0.792	0.740	1 1/64	1.042	0.990	1 1/64	1.042	0.990
1 1.0000	1 ½ 1.5000	1.450	⅞	0.903	0.847	1 1/8	1.153	1.097	1 1/8	1.153	1.097
1 ⅛ 1.1250	1 11/16 1.6875	1.631	1	1.030	0.970	1 ½	1.280	1.220	1 ½	1.280	1.220
1 ¼ 1.2500	1 ⅞ 1.8750	1.813	1 9/32	1.126	1.062	1 11/32	1.376	1.312	1 11/32	1.376	1.312
Special Sizes, For use During Transition Period											
7/16 0.4375	¾ 0.7500	0.728	3/8	0.394	0.356	5/8	0.644	0.606	5/8	0.644	0.606
9/16 0.5625	⅞ 0.8750	0.847	½	0.521	0.479	¾	0.771	0.729	¾	0.771	0.729
11/16 0.6875	1 1/8 1.1250	1.088	21/32	0.680	0.632	29/32	0.930	0.882	29/32	0.930	0.882
13/16 0.8125	1 5/16 1.3125	1.269	49/64	0.792	0.740	1 1/64	1.042	0.990	1 1/64	1.042	0.990
15/16 0.9375	1 ½ 1.5000	1.450	⅞	0.903	0.847	1 1/8	1.153	1.097	1 1/8	1.153	1.097
1 1/16 1.0625	1 11/16 1.6875	1.631	1	1.030	0.970	1 ¼	1.280	1.220	1 ¼	1.280	1.220

All dimensions are given in inches.

[1] Note:—The tolerance for the width across flats (W) shall be minus .050 D inches.

[2] Note:—The tolerance for the thickness of nuts (U and U_1) shall be plus or minus (0.016 D + 0.012) inches.

[3] Note:—The recessed type of nut shall have a recess of 1/8 inch minimum and 3/16 inch maximum.

[4] Note: Formulae for the width across flats are the same as given in the American Standard Wrench Head Bolts and Nuts. For special sizes, the width across flats is the same as for the standard of 1/16 inch greater bolt diameter.

[5] American Standard Rough Square and Hexagonal Nut.

Woodruff Keys, Key Slots, and Cutters

THE standardization of Woodruff keys is one of the projects undertaken by the Sectional Committee on the Standardization of Shafting, which was organized in October, 1922, by the A.S.M.E. as sponsor, under the procedure of the American Standards Association. The Sectional Committee at first gave its attention to the formulation of a Tentative American Standard for Cold-Finished Shafting. It later developed Tentative American Standards for Plain, Taper, and Gib-Head Stock Keys, and a Code for the Design of Transmission Shafting. Finally, in December, 1925, the standardization of Woodruff keys was undertaken by the Committee.

The Subcommittee on Woodruff Keys made a study of existing sizes and fits and in June, 1926, submitted to the larger users a preliminary proposal for review and criticism. Several revisions were found necessary before the proposal was approved by the Subcommittee, and on March 16, 1929, preliminary copies were widely distributed to industry for criticism and comment. The proposal has been further revised in accordance with the suggestions received and approved by the Sectional Committee.

Two typical tables showing the general design and dimensions of the keys and cutters, are reproduced here for the information of our readers, and comment will be welcomed on the Standard as proposed. Those who are more espe-

Woodruff Keys

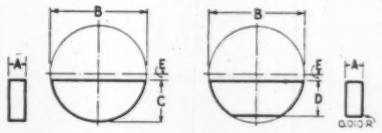


Table No. 1 Woodruff Key Dimensions

Key[1] Number	Nominal Key Size	Width of Key A		Diam. of Key B		Height of Key C		Height of Key D		Distance Below Center E
	A × B	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	
204	1/16 × 1/2	0.0635	0.0625	0.500	0.490	0.203	0.198	0.194	0.188	3/64
304	3/32 × 1/2	0.0948	0.0938	0.500	0.490	.203	.198	.194	.188	3/64
305	3/32 × 5/8	0.0948	0.0938	0.625	0.615	.250	.245	.240	.234	1/16
404	1/8 × 1/2	0.1260	0.1250	0.500	0.490	.203	.198	.194	.188	3/64
405	1/8 × 5/8	0.1260	0.1250	0.625	0.615	.250	.245	.240	.234	1/16
406	1/8 × 3/4	0.1260	0.1250	0.750	0.740	.313	.308	.303	.297	1/16
505	5/32 × 5/8	0.1573	0.1563	0.625	0.615	.250	.245	.240	.234	1/16
506	5/32 × 3/4	0.1573	0.1563	0.750	0.740	.313	.308	.303	.297	1/16
507	5/32 × 7/8	0.1573	0.1563	0.875	0.865	.375	.370	.365	.359	1/16
606	3/16 × 3/4	0.1885	0.1875	0.750	0.740	.313	.308	.303	.297	1/16
607	3/16 × 7/8	0.1885	0.1875	0.875	0.865	.375	.370	.365	.359	1/16
608	3/16 × 1	0.1885	0.1875	1.000	0.990	.438	.433	.428	.422	1/16
609	3/16 × 1 1/8	0.1885	0.1875	1.125	1.115	.484	.479	.475	.469	5/64
807	1/4 × 7/8	0.2510	0.2500	0.875	0.865	.375	.370	.365	.359	1/16
808	1/4 × 1	0.2510	0.2500	1.000	0.990	.438	.433	.428	.422	1/16
809	1/4 × 1 1/8	0.2510	0.2500	1.125	1.115	.484	.479	.475	.469	5/64
810	1/4 × 1 1/4	0.2510	0.2500	1.250	1.240	.547	.542	.537	.531	5/64
811	1/4 × 1 3/8	0.2510	0.2500	1.375	1.365	.594	.589	.584	.578	5/32
812	1/4 × 1 1/2	0.2510	0.2500	1.500	1.490	.641	.636	.631	.625	7/64
1008	5/16 × 1	0.3135	0.3125	1.000	0.990	.438	.422	.428	.422	1/16
1009	5/16 × 1 1/8	0.3135	0.3125	1.125	1.115	.484	.479	.475	.469	5/64
1010	5/16 × 1 1/4	0.3135	0.3125	1.250	1.240	.547	.542	.537	.531	5/64
1011	5/16 × 1 3/8	0.3135	0.3125	1.375	1.365	.594	.589	.584	.578	5/32
1012	5/16 × 1 1/2	0.3135	0.3125	1.500	1.490	.641	.636	.631	.625	7/64
1210	3/8 × 1 1/4	0.3760	0.3750	1.250	1.240	.547	.542	.537	.531	5/64
1211	3/8 × 1 3/8	0.3760	0.3750	1.375	1.365	.594	.589	.584	.578	5/32
1212	3/8 × 1 1/2	0.3760	0.3750	1.500	1.490	.641	.636	.631	.625	7/64

All dimensions are given in inches.

[1]Note: Key numbers indicate the nominal key dimensions. The last two digits give the diameter of the key (B) in eighths of an inch; the digits preceding the last two give the width of the key (A) in thirty-seconds of an inch. Thus, 204 indicates a key 2/32 A × 4/8 B or 1/16 A × 1/2 B; 1210 indicates a key 12/32 A × 10/8 B or 3/8 A × 1 1/4 B.

Woodruff Keys

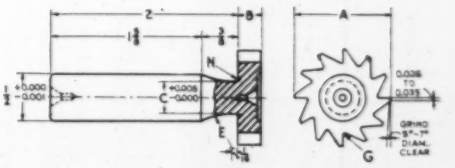


Table No. 3 Woodruff Keyslot Cutter Dimensions

Key[1] Number	Nominal Key Size	Number of Teeth		Cutter[2] Diameter A		Cutter[3] Width B		Neck Diameter		Radii			
		Fine	Coarse	Max.	Min.	Max.	Min.	C	C[4]	E	E[4]	G	H
204	1/16 × 1/2	10	8	0.515	0.510	.0625	.0620	.130		33/64		1/64	1/64
304	3/32 × 1/2	10	8	0.515	0.510	.0838	.0833	.180		3/64		1/64	1/64
305	3/32 × 5/8	10	8	0.640	0.635	.0838	.0833	.191		11/32		1/32	1/64
404	1/8 × 1/2	10	8	0.515	0.510	.1250	.1245	.191		11/32		1/32	1/64
405	1/8 × 5/8	10	8	0.640	0.635	.1250	.1245	.223		7/32		1/32	1/64
406	1/8 × 3/4	10	8	0.765	0.760	.1562	.1245	.217		15/32		1/32	1/64
505	5/32 × 5/8	10	8 1/2	0.640	0.635	.1562	.1558	.253		9/32		1/32	1/64
506	5/32 × 3/4	10	8	0.765	0.760	.1562	.1558	.247		7/32		1/32	1/64
507	5/32 × 7/8	12	9	0.892	0.887	.1562	.1558	.247		17/32		1/32	1/64
606	3/16 × 3/4	10	8	0.765	0.760	.1873	.1868	.279		1/4		1/32	1/64
607	3/16 × 7/8	12	9	.892	.887	.1873	.1868	.279		1/4		1/32	1/64
608	3/16 × 1	12	10	1.017	1.012	.1873	.1868	.279		1/4		1/32	1/64
609	3/16 × 1 1/8	12	10	1.142	1.137	.1873	.1868	.312		9/32		1/32	1/64
807	1/4 × 7/8	12	9	0.892	0.887	.2497	.2492	.342		21/64		1/32	1/64
808	1/4 × 1	12	10	1.017	1.012	.2497	.2492	.342		21/64		1/32	1/64
809	1/4 × 1 1/8	12	10	1.142	1.137	.2497	.2492	.373		3/8		1/32	1/64
810	1/4 × 1 1/4	14	10	1.270	1.265	.2497	.2492	.373		3/8		1/32	1/64
811	1/4 × 1 3/8	14	10	1.395	1.390	.2497	.2492		.401		3/64	1/32	1/64
812	1/4 × 1 1/2	16	12	1.520	1.515	.2497	.2492		.435		7/32	1/32	1/32
1008	5/16 × 1	12	10	1.017	1.012	.3121	.3116		.401		3/64	1/32	1/32
1009	5/16 × 1 1/8	12	10	1.142	1.137	.3121	.3116		.435		7/32	1/32	1/32
1010	5/16 × 1 1/4	14	10	1.270	1.265	.3121	.3116		.435		7/32	1/32	1/32
1011	5/16 × 1 3/8	14	10	1.395	1.390	.3121	.3116		.467		1/4	1/32	1/32
1012	5/16 × 1 1/2	16	12	1.520	1.515	.3121	.3116		.467		1/4	1/32	1/32
1210	3/8 × 1 1/4	14	10	1.270	1.265	.3745	.3740		.467		3/64	1/32	1/32
1211	3/8 × 1 3/8	14	10	1.395	1.390	.3745	.3740		.467		1/4	1/32	1/32
1212	3/8 × 1 1/2	16	12	1.520	1.515	.3745	.3740		.467		1/4	1/32	1/32

All dimensions are given in inches.

[1]Note: Key numbers indicate the nominal key dimensions. The last two digits give the diameter of the key (B) in eighths of an inch; the digits preceding the last two give the width of the key (A) in thirty-seconds of an inch. Thus, 204 indicates a key 2/32 A × 4/8 B or 1/16 A × 1/2 B; 1012 indicates a key 12/32 A × 10/8 B or 3/8 A × 1 1/4 B.

[2]Note: Diameters shown are set with the maximum diameter as that figure which will allow the cutter to be reground once or more, depending on the width.

[3]Note: Dimensions shown are set with minimum cutter width at minimum Key slot width. By adding to the maximum cutter width the amount it will cut oversize, a slot will be produced in the majority of cases just under the maximum Key slot dimensions.

[4]Note: For keys larger than number 810 cutters with cylindrical necks are specified. In these cases E is the small radius between the cylindrical necks and shanks.

A back clearance of .006 to .010 per inch, equivalent to 20 or 40 min., shall be ground on each side of the cutter.

A recess in each side of the cutter not deeper than 1/4 the cutter width, is permitted.

Concentricity: To be within 0.002 inch. Parallelism: Sides to be true within 0.0005 inch, indicator reading.

Marking and Manufacture: Cutters to be marked on shank with size and maker's name or trade mark. All burrs must be removed.

cially interested in the equipment covered and would care to make a more detailed review of the subject, may secure a copy of the complete proposal by addressing C. B. LePage, Assistant Secretary, A.S.M.E., 29 West 39th Street, New York, N. Y.

Correspondence

CONTRIBUTIONS to the Correspondence Department of Mechanical Engineering are solicited. Contributions particularly welcomed at all times are discussions of papers published in this journal, brief articles of current interest to mechanical engineers, or comments from members of The American Society of Mechanical Engineers on its activities or policies in Research and Standardization.

Early Hydraulic-Turbine Installation at Niagara Falls

TO THE EDITOR:

Referring to the papers of W. M. White and E. D. Adams in the April issue of MECHANICAL ENGINEERING, in which brief mention was made concerning some of the earlier hydraulic turbine installations at Niagara Falls, we believe the following particulars will be of interest.

We were the first engineers who designed and installed hydraulic turbines at Niagara Falls, under 215 ft. head, the highest head obtainable at the falls at that time.

At the time we designed these turbines there were no other equally as high-head horizontal-turbine installations in this country from which data could be obtained to assist in the designing of this development. Nevertheless, the performance of this installation was most successful and was the real stepping stone leading up to the larger hydro installations which were to follow.

In August, 1895, we contracted with the Niagara Falls Hydraulic Power & Mfg. Co., W. C. Johnson, Engineer, to build and install three horizontal-turbine units, each unit to develop 1700 hp. at 250 r.p.m. under 205 ft. head, driving direct-connected generators. At the time the turbines were ready for duty the maximum head of water was 215 ft.

These turbines were tested in place by A. F. Sickman, who at that time was hydraulic engineer for the Holyoke Water Power Co., Holyoke, Mass.

According to these tests the contract guarantees were exceeded in every particular, each unit developing 1900 hp., and as high as 85.5 per cent efficiency, an unprecedented record at that time for horizontal turbines.

Later we furnished additional turbines for this same installation. These turbines continued in service for many years, until the entire plant was dismantled to make way for turbines of more modern design and larger capacity.

THE JAMES LEFFEL AND COMPANY,
A. F. Sparks, *President.*

Springfield, Ohio.

The Conference Table

THIS Department is intended to afford individual members of the Society an opportunity to exchange experience and information with other members. It is to be understood, however, that questions which should properly be referred to a consulting engineer will not be handled here.

Inquiries will be welcomed at Society headquarters, where they will be referred to representatives of the various Professional Divisions of the Society for consideration. Replies are solicited from all members having experience with the questions indicated. Replies should be as brief as possible. Among those who have consented to assist in this work are the following:

ARCHIBALD BLACK, Aeronautic Division
A. L. KIMBALL, Applied Mechanics Division
H. W. BROOKS, Fuels Division
R. L. DAUGHERTY, Hydraulic Division
WM. W. MACON, Iron and Steel Division
JAMES A. HALL, Machine-Shop Practice Division
CHARLES W. BEESE, Management Division
G. E. HAGEMANN, Materials Handling Division
J. L. WALSH, National Defense Division
L. H. MORRISON, Oil and Gas Power Division
F. M. GIBSON and W. M. KEENAN, Power Division
W. R. ECKERT, Petroleum Division
MARION B. RICHARDSON, Railroad Division
WINFIELD S. HUSON, Printing Industries Division
JAMES W. COX, JR., Textile Division
WM. BRAID WHITE, Wood Industries Division

Applied Mechanics

Energy of Rotation and Revolution in Flywheels

AM-4 An unbalanced flywheel, heavily weighted in one sector, is so set up that its axis may be set revolving rapidly about a point lying in the plane of the flywheel. (See Fig. 1.) A high velocity of revolution is imposed on the axis of the flywheel, and at the same time a fast rotation about its axis is imposed on the flywheel itself.

It is the writer's understanding that, due to "centrifugal force," the weighted portion of the unbalanced flywheel will finally come to rest, as far as rotation is concerned, at the point farthest from the center of revolution. In other words, the energy of rotation will be changed completely into energy of revolution.

Suppose the flywheel, instead of being unbalanced, is perfectly balanced (see Fig. 2), and rotation and revolution are simultaneously imposed on it as before, either in the same or in opposite directions. Will there, in this case, by any tendency toward a transfer of the energy of rotation to that of revolution, or vice versa?

If there will be such a tendency, what equation could be used to calculate the tangential force acting on the axis of the flywheel in terms of the weight and radius of gyration of the flywheel, the radius of revolution of its axis, and the angular velocities of rotation and of revolution?

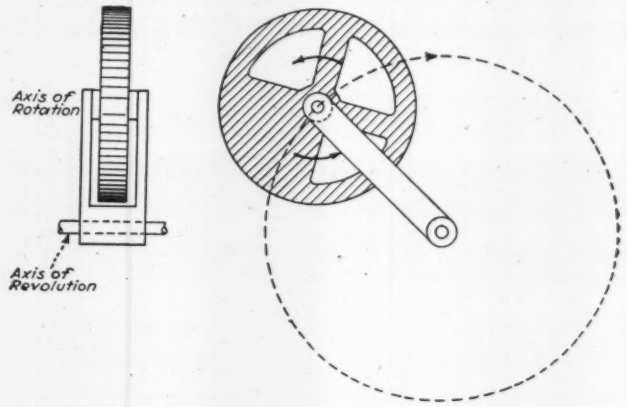


Fig. 1 Unbalanced Flywheel With Rotation and Revolution in Opposite Directions

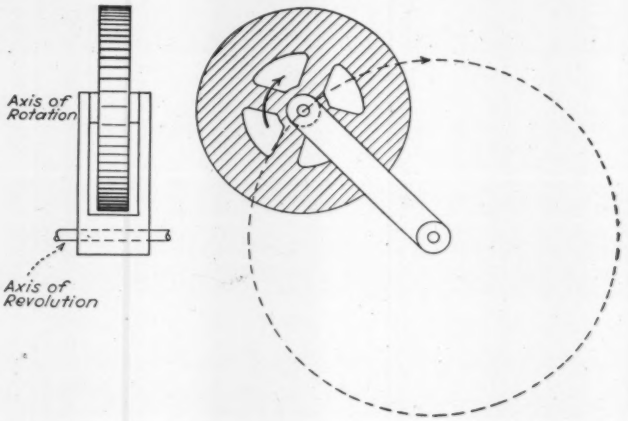


Fig. 2 Balanced Flywheel With Rotation and Revolution in the Same Direction

It appears that in either case energy will not be transferred from rotation to revolution due to centrifugal force. If there is friction in the wheel bearing, however, the case is different. The angular momentum of the wheel will then be transferred to angular momentum of revolution—in other words, the angular momentum of the system will remain the same regardless of friction. This is true whether the wheel be unbalanced or perfectly balanced. If there is friction in both bearings, the system will of course come completely to rest, its angular momentum being transferred to the earth. (A. L. Kimball, Research Engineer, General Electric Company, Schenectady, New York.)

Miscellaneous

Bending a Heavy I-Beam

M-3 It is proposed to bend a 9-in. I-beam of heavy section to a radius of 11 ft. 3 in. What methods are recommended to accomplish this without destroying the shape of the web of the beam?

Referring to the answers to question M-3 as published in the issue of Mechanical Engineering for May, 1930, it appears

that if a heavy heated I-beam be bent in the plane of the web to a comparatively small radius, the flanges will bend about the web toward the center of the circle unless some precaution is taken to prevent it. This is indicated by the broken lines in the accompanying sketch (Fig. 3).

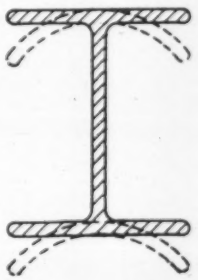


FIG. 3 POSITION OF FLANGES IN BENT I-BEAM

Again, if an endless ring be made of the I-beam and this be loaded as a cylindrical shell with internal pressure, owing to the thinness of the flanges in proportion to their overhang, the outer edges of the flanges would carry very little of the radial load, but this would be carried mostly by the web, unless many gussets were put in or other precautions taken to distribute the load. (F. W. Salmon, Civil and Mechanical Engineer, Birmingham, Ala.)

Questions to Which Answers Are Solicited

USE OF PULVERIZED COAL FOR FIRING SHAFT LIME KILNS

F-14 Has a direct-fired pulverized-coal system ever been used to fire shaft lime kilns? If so, give brief description, together with results obtained, difficulties encountered, and data on operation.

CONVEYING SAND HYDRAULICALLY

M-10 It is planned to convey sand from a washer to a height of 20 ft. above the washer by means of water injected at high velocity through a nozzle into a 5-in. pipe. Does this arrangement seem feasible, or will the quantity of water to be disposed of offset the advantages gained by the elimination of mechanical apparatus?

ETCHING NUMBERS ON THICKNESS GAGES

M-13 What is an inexpensive method of etching numbers on thickness gages? A rubber stamp dipped in acid has been tried, but with acid strong enough to etch the impression clearly, the rubber stamp is corroded.

CUTTING A GROOVE IN HARD ROCK

M-14 How can a groove $1/2$ in. deep and from $1/2$ in. to $3/4$ in. wide be machined at one cut in hard rock at a speed of 60 in. to 75 in. per min.? What power will be required, and what material and shape is necessary for the tool?

TIME ALLOWANCE FOR WASHING UP

Mg-4 What time allowances are made laborers in manufacturing plants for washing up at the end of the morning and afternoon periods, and for lunch about the middle of the morning period?

CAUSES AND REMEDIES FOR CINDER CUTS IN BOILER FLUES OF LOCOMOTIVES

R-4 What are the causes and satisfactory remedies for cinder cuts in the flues of steam locomotives? They occur both inside the firebox above the firebricks at the boiler head and also in the front end or smokebox.

LATEST DEVELOPMENTS IN THE LONG-DRAFT SPINNING OF COTTON YARN

T-2 What are the latest developments in long-draft spinning of cotton yarn? Has any system of long-draft spinning been generally adopted in this country?

A.S.M.E. Boiler Code Committee Work

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Any one desiring information as to the application of the Code is requested to communicate with the Secretary of the Committee, 29 West 39th St., New York, N. Y.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and passed upon at a regular meeting of the Committee. This interpretation is later submitted to the Council of the Society for approval, after which it is issued to the inquirer and published in MECHANICAL ENGINEERING.

Below are given records of the interpretations of the Committee in Cases Nos. 647, 648, and 649, as formulated at the meeting on April 25, 1930, all having been approved by the Council. In accordance with established practice, names of inquirers have been omitted.

CASE NO. 647

Inquiry: Is it permissible, under the rules of the A.S.M.E. Boiler Construction Code, to construct low-pressure heating boilers of open-hearth iron plates? It is noted that there is no existing specification in the Code for such material.

Reply: The Committee announces that a proposed specification for open-hearth iron plates has been under preparation by the American Society for Testing Materials which is soon to be published in tentative form. It is the opinion of the Committee that pending final report and ballot upon this proposed specification, which is entitled "Proposed Tentative Specifications for Open-Hearth Iron Plates of Flange Quality" (a copy of which is on file in the records of the Boiler Code Committee), low-pressure heating boilers may be constructed of this material under the provisions of Section IV of the Code, provided the material conforms to the requirements of the Proposed Tentative Specifications.

CASE NO. 648

Inquiry: Is it permissible, under the requirements of Par. P-200 of the Code, to weld reinforcing plates to the inside of a shell for staybolts inclined to the surface, in order to provide thickness for the necessary three engaging threads, of which at least one must be a full thread?

Reply: It is the opinion of the Committee that this is not permissible, because under Par. P-186 fusion welding is permitted only where it is used solely for tightness and not for strength.

CASE NO. 649

(In the hands of the Committee)

THE curiosity metal, indium, only about a pound of which has been isolated from its ores, is produced 99.9 per cent by pure electrolysis. Although it is very rare and brings about six times as much as platinum, it is hoped that a use will be found for its peculiar properties. It melts at a much lower temperature than tin, and is very soft and ductile.—*Science*, June 6, 1930, p. xii.

MECHANICAL ENGINEERING

A Monthly Journal Containing a Review of Progress and Attainments in Mechanical Engineering and Related Fields, The Engineering Index (of current engineering literature), together with a Summary of the Activities, Papers, and Proceedings of

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Contributions of interest to the profession are solicited. Communications should be addressed to the Editor.

BY-LAW: The Society shall not be responsible for statements or opinions advanced in papers or . . . printed in its publications (B2, Par. 3).

Elmer A. Sperry

ELMER AMBROSE SPERRY, past-president of the A.S.M.E., died suddenly at the St. John's Hospital, Brooklyn, N. Y., on June 16, 1930. Thus ended the career of one of the most enthusiastic and prolific inventors of our times. Possessing a heritage of Yankee ingenuity and living at a time when inventions held spectacular opportunities and rich rewards for ingenious men with active minds and tireless energies, Mr. Sperry was the author of numerous unique and important contributions that ranked his name with those of Westinghouse and Edison. His active life was coincidental with the development of the electrical industries to which he made important contributions. Best known of these are his perfection of one of the first arc-light machines and the improvement of the high intensity searchlight. He is most popularly known for developments in the application of the gyroscope to safety and comfort in marine and aerial navigation—the "metal mike" and the gyroscopic compass and gyroscopic stabilizer for ships and aircraft. In his passing the world loses an industrious and useful inventor whose unique qualities are not frequently encountered.

Commencement

THIS is the time of year when hundreds of graduates of engineering colleges will face this world on their own for the first time. Perhaps the man who will take up your work when you lay it down will walk into your office, a raw youth, to begin his career. How will you receive him? What will you do for him?

It is probable that he is facing a more difficult situation than you faced when you stood in his place. Competition yearly grows more keen, responsibilities increase, the acceleration of change brings more serious problems, economic conditions become more complex. He must continuously exercise greater vigilance to maintain his status among other men, for he will find fortune more fickle.

Remember that he is accustomed to intellectual stimulation, and that his success will depend upon mental suppleness and alertness. Help him to avoid the dangers of monotonous mechanical routine. Help him to realize this and encourage him in additional and continued study. Urge him to associate himself with local and national groups of engineers and to take an active part, when opportunity arises, with their professional activities, and to make use of the services they may be able to render him. The responsibility of training the engineers of the next generation rests squarely with those of this.

The Six-Hour Day in the Sheet Mills

THE principal demand of the Wage Committee of the powerful Amalgamated Association of Iron, Steel, and Tin Workers at the Wage Conference held recently at Atlantic City was for a six-hour day.

There are a good many reasons why such a demand should be made now. In the first place, with the introduction of certain modern improvements and the adoption of the so-called Tipperary scheme of rolling, the output of the sheet mills has increased tremendously without a corresponding increase in the man power employed. The work in the sheet mills is hard and its reduction to six hours, besides increasing the number of men employed, would be also very beneficial to the health of the workers. Whether from the point of view of economic policy this is the right time to make such a demand, is a question. The continuous sheet mill has already taken away some of the work that would otherwise have been done in hand mills. The introduction of the cold-process mill where the metal is drawn through rolls instead of being rolled will also take up a part of the hand-mill production, and only the future, probably not a distant one, will show just what share this will be. At a time, therefore, when the machine is more and more encroaching upon man power in the steel mills, the demand for a six-hour day may act as a powerful accelerator in the direction of employment of machinery. The automatic tinning pot and automatic doubler have done their share. The automatic catcher is unquestionably under way. On the other hand, however, if the Amalgamated Association should succeed in introducing the six-hour day without disastrously affecting the cost structure of sheet manufacture, this will be viewed with favor by other classes of workers on the ground that, the last hours of the present working day being the least productive, there is good reason to believe that a general shortening of the working day might ultimately be achieved without sacrificing either volume of output or cost of production.

The Reasons Why

THE engineer is often in the position of the man who builds better than he knows. As pointed out in an abstract of Professor Southwell's lecture and comment thereon in *The Engineer*, published in this issue, modern mathematical theories can prove most beautifully why an airplane flies, but they do it in a way which also proves that it is not necessary to have an engine to keep the airplane going. This is one very clear case of a theory being too good to be true—and, of course, it is not true, as its own proponents know. Nevertheless engineers are building planes that fly, although they do not know *why* they fly.

There are numerous instances of engineers' doing things right either without knowing why they are right or in the face of

theories that would indicate quite the contrary to what happens. Some years ago a very elaborate investigation of radiation phenomena in furnaces was undertaken in Germany with a view to improving the performance of soaking pits, billet heating, and open-hearth furnaces. This investigation was a very useful one as it brought out a number of factors dealing with radiation and selective absorption of heat by gases in furnaces. It did not, however, contribute to any material improvement in the design of furnaces, as when the results of investigation were applied to check existing furnaces it was found that they were in practically full agreement with the newly devised theories.

Another instance of doing things right without knowing why has to do with the rolling of german silver. This material was found to be too brittle for rolling except at one mill where they were rolling it quite satisfactorily. All attempts to discover the secret of this through analysis failed, as analysis indicated that the standard german-silver composition was being used. Some time later, however, it was discovered that that particular mill made its ingots not out of virgin metal but out of german-silver scrap; and it was only quite recently that we began to surmise that in scrap metal there may be impurities acting as catalysts and bringing about a structure materially different from that of virgin metal only, though we cannot as yet tell why this happens. And yet there was an engineer who felt that it would happen, and, surprisingly enough, it did.

Even in distant antiquity things were done and done successfully for which we are only now learning the reasons. When the Jews in Egypt refused to make bricks without straw it was not mere perverseness on their part but the result of inability to make bricks as fast as they could be made with straw. Either by observation or by remarkable discernment some Egyptian brick maker discovered that by adding straw he could make bricks better and quicker, and it is only within the last twenty years that we have found out that clay, being a colloidal mass, coagulates differently and more rapidly in the presence of certain organic materials incidentally produced from straw.

Our theoretical knowledge has advanced far indeed, and is progressing at a tremendous pace. At the same time it is important to remember that this knowledge still has material limitations, and the man who in his thinking is a slave to mathematical analysis may prove to be as much in the wrong as the man who rejects theory completely as being something "high brow" and impractical. Any one who thinks that we are already in a position to predetermine by analysis what may happen in a new structure or a new process, need only lift his eyes to the first airplane flying over his head and humbly remember that while we can make an airplane fly, we cannot explain why it does so.

It is quite the fashion to sneer at Simon Newcomb, who some thirty years ago proved mathematically that an airplane could not fly. Today Lanchester and Prandtl are from a mathematical point of view only a little ahead of Newcomb. The only difference between the mathematician of today and Newcomb is that the former does not have enough confidence in his mathematics to deny the facts that are noisily proclaiming their existence every time that an airplane flies. A theory is a very excellent thing, but a fact—if it is a fact—is a very difficult thing to controvert by mathematical analysis.

Tails Wagging Dogs in Industry

THE original idea of a by-product was a material which was produced incidentally to the major performance of manufacture, and as such was expected to carry a minor share of the total cost burden. Cases have been known from time to time in which the by-product developed to the point where it became the main product, but it is only within the last few years, when a very determined effort has been made to utilize every possibility of production, that such a situation as that of the tail wagging the dog has become increasingly common.

Some years ago a man discovered that sugar cane could be used to produce a structural material which is now known under the trade name of Celotex. At that time, of course, cane had very little value, as it did not even make a good fuel. So great, however, has been the development of celotex, that it is becoming more and more the main product, with sugar, in that particular organization at least, as a by-product.

In industrial power plants as installed where there is a large demand for heating and process steam, the balance between the two, i.e., power and steam, is sometimes so delicate that it is not clear which is the primary and which the secondary. The revival of the reciprocating steam engine for use as a prime mover in such plants is largely due to the fact that this engine is usually well adapted to effect a compromise between power demand for one kind of steam and process demand for another kind.

Historically, probably the most impressive case of the tail not only wagging the dog but growing to a size many times that of the dog, is in oil refining. Only a generation ago the products of oil refining were kerosene and lubricating oils, while gasoline was the bane of life of the oil refiner. There was not enough demand for it for such purposes as cleaning clothes. There was no safe way of burning it, and the refineries were not allowed to discharge it into rivers. Then came the motor car, and suddenly there was a greater demand for gasoline than for kerosene, until ultimately special methods had to be developed to convert into the previously despised gasoline a share of the heavier fractions.

One such revolution in one of the oldest branches of American agriculture is taking place right now. Quite recently a method has been discovered for converting corn cobs into a structural and insulating material which incidentally may come to compete with celotex, above referred to, and similar products. If what has been announced in regard to this development is true, there will be a big demand for corn cobs, with a consequent rise in their price which may materially affect the cost of production or price of the corn. Little did Hiawatha think when he buried Mondamin after his fight that not only the succulent grain but the useless cob would find an application in industry. This utilization of by-products will occur more and more frequently with the further progress of industrial chemistry. Already in blast furnaces the top gases are used for firing boilers and as fuel for gas engines, while the slag is converted into cement. This may be one reason why, with the great increase in the cost of labor, a practically similar increase in the cost of fuel, increase in the cost of ores, and higher rates of ore transportation, the cost of pig iron has not increased in the same proportion as have the factors that enter into its manufacture. It is therefore more and more important for the engineer to become acquainted with such basic processes of industrial chemistry as are apt to affect the cost of his materials.

A clear distinction must of course be made between industrial by-products and technical by-products. By the former we mean products other than the primary ones for the sake of which the manufacture is undertaken. Technical by-products are those which are obtained in the course of another process. An excellent illustration of the latter is the electric-lighting industry which, technically (using the terminology of this editorial), is all tail and no dog. The electrical energy is used to heat a filament in a glass bulb. The heat, however, is not wanted at all. What is wanted is the light radiation from the filament incident to its heating. Industrially the light is the final product of applying electric current to the filament. Technically it is merely a by-product, and if a way were found to utilize the heat of the filament, the heat would become the main product. As a matter

of fact, in a so-called radio tube this heat is utilized for the emission of electrons, and where this is done the by-product, light, which in a radio tube is nothing more than a faint glow, is properly neglected. The foregoing shows the complexity of the relation between the main product and the by-products, and the necessity for clearly distinguishing between the case where the tail is merely an appendage and that where it has grown so important that it actually wags the dog.

Gas Turbines

THE internal-combustion-turbine designer has an unusually tough problem before him, for this new prime mover comes into competition with existing devices under particularly difficult conditions. It took a long time to develop a truly satisfactory internal-combustion reciprocating engine, such, for example, as is used today in motor cars. The older generation still remembers distinctly the demand for horses to pull an automobile when its engine, as a result of one of its numerous ailments, refused to do so. The automobile of today, as a matter of fact, bears witness to the unsatisfactory performance of the early engines, as it was mainly to make the engine accessible in case of trouble that it was located at the front of the car. Logically, of course, it should be in the rear, under the body. When, however, the automobile engine first appeared there were practically no competitors to it in the motor-car engineering field. The development of the steam automobile was half-hearted and inconsiderable. The public wanted automobiles so badly that it was even willing to put up with unsatisfactory performance, and this made it possible to develop the automobile internal-combustion engine to its present state of excellence.

Practically the same situation existed with respect to steam turbines. So huge and unwieldy were the reciprocating engines of forty years ago that the value of a small, simple, and reliable prime mover was obvious enough to warrant the most serious consideration. The development of the alternator also demanded the invention of a high-speed prime mover, all of which led to the rapid development of the steam turbine.

When we come, however, to the internal-combustion turbine, the situation is entirely different. In small sizes it has to compete with the well-developed explosion-type engine; in larger sizes the Diesel engine looms as a powerful rival; and there is but little hope that it will ever be capable of competing with the big steam turbine. The engineering community has such a wealth of types to choose from, all of them splendidly developed, that it is not at all keen to accept the internal-combustion turbine unless it can be shown to be fully reliable and superior to some existing type in some particular feature. This means that it is not being given an opportunity to improve with time and use, but, like the famous Greek goddess who appeared in all of her beauty from the ocean foam, the internal-combustion turbine is expected to burst suddenly upon the world in a fully perfected state. Things seldom happen that way in real life.

This is all the more so in view of the high state of development of other prime movers. The straight-8, V-12, and 16-cylinder engines are already remarkably free from vibration. The Rolls-Royce R engine used in the Schneider trophy race by the British plane has an engine weight of the order of $^3/_4$ lb. per hp., and the designers claim that even this can be materially reduced if desired. Therefore it will not be easy for the internal-combustion turbine to compete with the gasoline engine as regards weight.

When it comes to fuel consumption, it is hardly to be expected that the internal-combustion turbine will shine particularly. Its air compressor is difficult to design and does not promise to be of especially high efficiency. All the conditions of operation are such as to make losses here and there apparently greater than those encountered in reciprocating engines. While, however, the problem is a difficult one, there is no lack of engineers who, thoroughly realizing that they are undertaking a tough job, have the courage to go into the development of this new type of prime mover—which is a warrant that if the internal-combustion turbine does contain possibilities that will make for it room in the crowded scene of prime movers, this will be done.

An important sidelight on the prime-mover situation in general is thrown by the paper entitled "Economic Considerations in the Application of Modern Steam Turbines to Power Generation," by Prof. A. G. Christie, published in this issue.

As a result of a comprehensive analysis of the various features of turbine operation, the author comes to the conclusion, among other things, that it would have been next to impossible to meet the power requirements that now exist in large electrical systems with reciprocating gas or Diesel engines. The development of the steam turbine has been stimulated more by the demand for capacity than for improved efficiency, although satisfactory gains in economy have been achieved with increase in size. This is one more proof of the general idea that a prime mover in order to compete successfully with other prime movers must excel them in at least one feature. The steam turbine has the capacity of increasing in size to an extent the limit of which we do not yet know. The Diesel engine has a high fuel efficiency and the ability to start quickly. The gas turbine must develop a point of excellence of its own in order to find a place in the healthy family of present-day prime movers.

Another interesting sidelight on the power situation is given by Professor Christie in the statement that the efficiency of a given type and size of turbine is regulated by competition and by advances in the art of design and construction. No manufacturer furnishes the most efficient turbine that he is capable of building, but merely supplies at the current market price a turbine of about the same thermal efficiency as that of his competitors. This condition leads to low turbine prices, but does not always insure that the most economical turbine is furnished, taking into account both efficiency and fixed charges. It is of interest to consider this situation as compared with the one existing in the manufacture of airplane engines, where apparently price is no object and superior efficiency, reliability, etc. are the governing considerations. Those who complain of high prices of airplane engines as compared, for example, with somewhat similar automobile engines might do well to read Professor Christie's paper. One cannot buy utmost excellence at current market prices. Incidentally, Professor Christie's remark would indicate that there is actually available a large dormant reserve of engineering progress in the field of steam turbines, a thought rather disturbing to the inventor or designer having his eye on this field.

Coker F. Clarkson

COKER F. CLARKSON, for twenty years secretary of the Society of Automotive Engineers, died at his home, Sleepy-Hollow Farm, Scarborough-on-Hudson, on June 4. Mr. Clarkson's long connection with the automobile industry during the period of its remarkable expansion gave him an important and unique position in it. Through the S.A.E., automobile manufacturers and engineers were brought together in a program of standardization and general development that has been one of the important influences in the strong position occupied by the industry. Mr. Clarkson's leadership in the program and his influence in its development contributed largely to its success. This success justifies the existence of such organizations as the S.A.E. Mr. Clarkson's name will always be connected with the history of one of the greatest industrial developments that the world has seen.

The Warner & Swasey Company's Fiftieth Anniversary

A Brief Account of the Celebration of the Semicentennial of the Renowned Engineering and Manufacturing Organization Founded by Two Past-Presidents of the A.S.M.E.

ON MAY 23, 1930, more than twenty-five hundred people gathered on the machinery-assembly floor of the Warner & Swasey plant in Cleveland, to join with the surviving founder in celebrating the fiftieth anniversary of this engineering and manufacturing organization. The place of the gathering, the character of the audience, and the nature of the ceremony were typical of the spirit which has animated the Warner & Swasey organization from the time of its inception. The event effectively demonstrated that an industrial project can be developed as an institution just as truly as can a university. It was the privilege of the writer to be seated during the ceremonies with those who were Warner & Swasey workmen and who had "learned their trade" in this shop. No alumni group could evince any greater pride in its alma mater than did these people in the institution of which they feel themselves actually to be a part.

The affair might well be described as a "family party."

MEDAL COMMEMORATING FIFTIETH ANNIVERSARY OF THE WARNER & SWASEY CO.

"Members of the family" who were present included the humblest workmen—with their wives and children—as well as the directors and the president of the corporation.

"Friends of the family" who were present included former apprentices—many of whom have made names for themselves elsewhere in the industrial world—educators, scientists, officers of learned societies, and industrial leaders. All of these sincerely joined in honoring their living patron and associate, Ambrose Swasey, and in honoring his deceased partner, Worcester Reed Warner, co-founder of the company and likewise a patron of the arts and sciences.

Brief mention of the program of ceremonies that marked the Anniversary was made in the June 7 issue of the *A.S.M.E. News*.

MR. SWASEY'S ADDRESS

To have been active in the guidance of a large business enterprise throughout a period of fifty years is itself an unusual achievement, but for a man who was born in the year 1846 to be able to stand before a large audience and deliver a stirring address in the year 1930, is little short of extraordinary. This Mr. Swasey did as part of the afternoon's program.

In reviewing the past half-century, he said: "Since we took up this work, great things have happened in this world. Mr. Warner and I did not realize—nor did we dream—of the great changes which have come to this great country, to this nation, and to this old world of ours. Think of the changes and the advancements that have taken place on the earth, in the earth, on the water, under the water, in the sky.....I am sure that we should have been uneasy about the little plant we started if we had known all that was going on, and of the possibilities of the future. So often in life it is well that we do not know the future."

Mr. Swasey paid special tribute to the metallurgists for the part which they have played in the industrial revolution. As an illustration of the effect of their work he mentioned that the introduction of high-speed steel had made it possible for one machine tool to do as much as was formerly done by eight. He said, "I am confident that if it had not been for that discovery by the metallurgists, we should not have as many automobiles on our streets today, because it would not be possible to turn them out with the present rapidity." He further predicted that developments now under way in materials for still higher-speed metal cutting will eventually lead to another revolution in the machine-tool industry fully as sweeping as was that one brought about by the introduction of high-speed steel.

In closing, Mr. Swasey said: "I wish to say a few words relative to my former partner Mr. Warner, who passed away about a month less than a year ago. We had been associated for sixty-three years. We first met down in Exeter, New Hampshire, my old home town, in a little machine shop where we were learning the machinist's trade together. Throughout all these years we have journeyed on as associates and friends, partners in business. I want to say to you that he was one of the dear men of this world, always interested, always living on such a high plane, always such an inspiration to so many with whom he came in contact. I can express it in no better words than he was indeed one of God's noblemen."

THE FUTURE ENVISIONED BY DEAN KIMBALL

Dean Dexter S. Kimball, of Cornell, who made the only other address, said that he accepted the invitation to speak at this gathering with peculiar pleasure—not only because of his years of friendship with the founders of the company, but also because it gave him an opportunity to address a group to which he particularly belonged. He said, "I was a machinist, and I was a good one. There is nothing in your business that I don't know and haven't gone through, making my own share of mistakes. Therefore it is a pleasure for me to talk to an audience of this kind."

Dean Kimball touched upon the history of engineering, and pointed out the important place held by the turret lathe in this history. Basing his suppositions upon the wonders of the present, he made some predictions as to engineering wonders which the future holds in store. He mentioned the new Hudson River suspension bridge, and predicted bridges a mile between abutments if need be. With a compound power unit of 300,000 kilowatts now a fact, he saw power houses capable of 5,000,000 kilowatts as possibilities in the future. Other possibilities visioned by Dean Kimball were 1000-ton locomotives, 70,000-ton ships, and pocket radio receivers.

THE STORY OF THE WARNER & SWASEY COMPANY

As a feature of the commemoration of its fiftieth anniversary, The Warner & Swasey Company distributed a beautifully made book telling of the history of the company, the development of its products, and something of the lives and work of those men who have contributed to its upbuilding and to its management.

In brief, the history is as follows: Worcester Warner—born on a farm in the Berkshire Hill township of Cummington, Massachusetts, on May 16, 1846—and Ambrose Swasey—born at Exeter, New Hampshire, on December 19, 1846—began their lifelong association as apprentice machinists at the Exeter Machine Works in 1866. In 1870 they went together to the Pratt & Whitney Company in Hartford, Connecticut, where for ten years they worked hard, and studied hard, and became foremen over important departments. They became convinced that the Middle West offered great possibilities to the builder of precision machine tools. In 1880 they pooled their financial resources to the extent of $12,000 and began business in Chicago. They quickly discovered that they had gone too far west to get the necessary skilled workmen, so they made a new start in Cleveland. In that city they prospered, and within less than ten years they had written their names large in the realms of machine tools and of astronomical instruments.

Their turret lathes are today in use the world over. Among the great telescopes built by them are the 40-in. Yerkes instrument; the 72-in. reflecting telescope of the Canadian Government; the 60-in. instrument in the Argentine National Observatory, and the 60-in. instrument for Ohio Wesleyan University. Range finders, gun sights, etc. were also produced in quantities during the World War.

ASSOCIATIONS WITH BRASHEAR

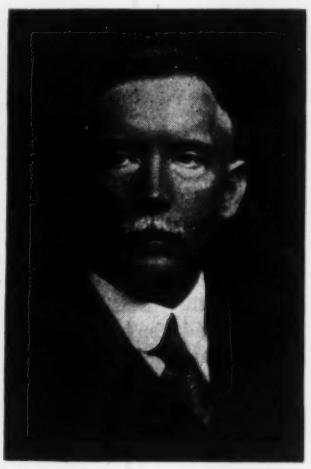
Mention of these optical instruments brings to mind the years of close association between Worcester Warner, Ambrose Swasey, and that lovable character, master workman, and scientist known to hundreds of people as "Uncle John" Brashear. It was John Brashear who ground and polished the lenses and mirrors which are the optical elements in many of the Warner & Swasey telescopes. Thus was the work of these three self-educated engineers and scientists closely bound together. It is a matter of pride to The American Society of Mechanical Engineers that all three of these great characters gave liberally of their time and talents to the work of the Society, that they all served as presidents of the Society, and that the names of all three appear on the roster of its honorary members.

Engineers everywhere warmly congratulate Ambrose Swasey and his associates upon the splendid traditions, as well as the substantial material success, built up by the Warner & Swasey organization during its first fifty years. Here, indeed, is an institution which is the lengthened shadow of men—not of one man, as the proverb goes, but of a harmonious group of masters of their craft.

GUY HUBBARD.

James Edward Sague

1862–1930



JAMES E. SAGUE

JAMES EDWARD SAGUE, for many years connected with Worthington Pump and Machinery Corporation, died at Cliffdale, his Poughkeepsie, N. Y., home, on May 9, 1930.

Mr. Sague was born at Poughkeepsie on July 20, 1862, the son of Horace and Harriet Jane (Kelsey) Sague. He was graduated from the Stevens Institute of Technology at Hoboken, N. J., in the class of 1883, receiving the degree of M.E. His graduation thesis covered "A Report on the Trial of the Steamer *City of Fall River*," and was published in the *American Engineer* and the *Journal of the Franklin Institute*.

From 1883 to 1892 he was engaged in railroad work. During this time he spent two years as mechanical engineer for the West India Improvement Company and master mechanic of the Jamaica Railroad, Jamaica, W. I., following which he was engaged with the Schenectady Locomotive Works from 1892 to 1901.

From 1901 to 1907 he was chief mechanical engineer and later as vice-president of the American Locomotive Company.

During the first administration of Governor Hughes in 1907, Mr. Sague was appointed a member of the Public Service Commission for the Second District, controlling all public utilities in New York State outside of New York City. He held this office for seven years with great credit to the Commission and himself. While with the Public Service Commission, he was chosen chairman of the Committee on Rails and Equipment of the National Association of Railroad Commissioners.

In 1916 the American Manufacturers Export Association organized the American Industrial Commission. This commission visited France to ascertain how American resources might best be made available for the reconstruction of the devastated regions and with the hope of furthering Franco-American trade relations. Mr. Sague was a member of this commission.

In June, 1916, he was chosen chief consulting engineer of the Worthington Pump and Machinery Corporation. March 1, 1918, he was elected a member of the board of directors and vice-president in charge of engineering and manufacturing, and as such directed Worthington's large production of war material.

Mr. Sague resigned as vice-president of Worthington in 1926, but remained a director of the company until his death.

For several years prior to his death he was chairman of the Reorganization Committee of the Middle States Oil Company, and upon its rehabilitation this year as the Middle States Petroleum Company he became a member of the board of directors and a voting trustee. He was at the same time president of the Sague Realty Company of Poughkeepsie.

Mr. Sague was married in 1890 to Miss Jeanette Kenyon of Brooklyn, N. Y.; and after her death to Miss Mary Landon, a professor at Vassar College, who, together with his daughter, Mrs. Sterling Carter, of Poughkeepsie, survives him.

Mr. Sague joined the A.S.M.E. in 1887, and was vice-president of the Society in 1914–1916.

The A.S.M.E. Meeting at Detroit

Some Observations on an Engineering Event of Major Importance

DETROIT is a city that is characteristic of the engineering era in which we live. Evidences of this are to be found on every hand. It is known the world over on account of the automobile industry, and is symbolic of the modern industrial civilization which has brought such prosperity to America and has caused such bitter attacks on the part of perplexed philosophers. Its great factories with their assembly lines engaged in the most up-to-date production methods are institutions of today, representing the perfect coordination of many complex and variable elements. Orderliness such as comes from careful planning and attention to the details of the result to be accomplished is one of the characteristics of these establishments that wins the approval of engineers. The abundant use of labor-saving machinery and of power is also an evidence of an engineering community. Here are such famous central stations as Delray, Connors Creek, Trenton Channel, wherein the engineers of the well-known Detroit Edison Company have shown evidences of inspiring and progressive leadership, and have experimented with the advanced developments in power engineering. Through the medium of the engineering meeting and technical journal, the results of work done in this field have been broadcast to the world, bringing the name of Detroit once more before the world for its contributions to this important branch of engineering science.

As a place in which to hold an engineering meeting, therefore, Detroit is ideal. This was amply proved by the success of the Semi-Annual Meeting of the A.S.M.E., June 9 to 12. Here there was an opportunity of hearing excellent discussion of many important technical papers, of visiting the famous industries of Detroit, and of seeing in practice the many engineering features of the locality in which mechanical engineers have a deep interest. By devoting the mornings to technical sessions, the afternoons to inspection trips, and the evenings to social gatherings, all three of these important phases of an engineering convention were served without interference.

The arrangements for the meeting were excellent. At the Book-Cadillac Hotel, which served as headquarters, it was possible to confine the activities of the meeting to the ballroom floors where there were enough rooms to provide for four simultaneous sessions, registration, ladies headquarters, and numerous committee gatherings without the confusion sometimes experienced because of interference with the routine functions of the hotel.

Detroit Host of Society for Fourth Time

This is the fourth time in the history of the A.S.M.E. that the spring meeting of the Society has been held in Detroit. In point of total registration, however, this year's meeting was a disappointment to the local committee, which felt that 638 was too small a figure. However, excellent reasons exist for smaller attendances at spring meetings than were the rule when fewer meetings were held. Meetings of engineering and related organizations have been particularly numerous during the spring of 1930, both in this country and abroad.

But if the numbers were disappointing to the local committee that exerted such splendid efforts in arranging the program and carrying out its details, those who attended were well repaid and expressed themselves enthusiastically as being deeply appreciative of every feature. Too much cannot be said in praise of the very excellent technical program, on which were represented so many local engineers in whose papers the high quality of work accomplished in the vicinity of Detroit was evident. The opportunity which was presented of visiting the industries of Detroit under the circumstances of the meeting and the sponsorship of the Local Section meant quite as much to many engineers as did the sessions at which the technical papers were discussed. Every one will remember the boat ride on the Detroit River and Lake St. Clair. This has been an attractive feature of previous meetings in Detroit. It was an evidence of the most cordial hospitality to repeat this enjoyable experience in 1930. In every respect the Detroit Section has set a standard of excellence and hospitality that others who act as hosts of the Society at its semi-annual meetings will find it difficult to maintain.

At the technical sessions, an observer of many years standing commented on the difficulty with which the presiding officers in some instances drew discussion from the audience. Admitting the many excellent reasons for this condition, one still regrets that discussions are not more lively. There is, in some cases, a deplorable tendency for the lion and the lamb to lie down together in public. A naive observer may easily imagine a greater agreement in matters of opinion than actually exists. The opportunity for a frank discussion of all sides of an engineering problem is presented at meetings of the Society, and it is natural to expect that many points of view will be expressed. This forms as important a part of the program as does the reading of the paper. If discussion is not forthcoming from the audience, it would be cheaper to stay at home and read the paper in the quiet of one's study. Of course the responsibility rests with the audience itself, from which the discussion must come. If every one would feel this responsibility the discussion of a paper would soon develop such activity that there would not be time to hear it all. But every one would have a more profitable time, and many modest engineers who now sit on the sidelines to listen would become better known and make reputations for themselves among their fellows. Strangely enough, papers read before the Applied Mechanics Division provoke plenty of discussion, although they are usually of a type that requires the most careful study both to present and to discuss. While this discussion is likely to be academic, its frequent reversion to basic principles is always refreshing, and the sharp criticism that is sometimes expressed results in improvements in the quality of the papers as they are published in the Transactions.

Tungsten Carbide Cutting Tools the Subject of Extended Discussion

There was no lack of interesting and valuable discussion at the session at Detroit at which tungsten carbide cutting tools were discussed. The subject is important, and is still new enough to provide a source of questions and of differences of opinion. Two of the papers that were presented at this session will be found elsewhere in this issue. They deal with the experiences of one firm with tungsten carbide in cutting cast iron, and with the adaptation of it by another company to the cutting teeth of circular saws.

An important and valuable function is being performed by the A.S.M.E. in connection with this new cutting material. When it was first introduced commercially, it was, naturally, such a novelty that it attracted instant attention. The spectacular

feats performed by it and attributed to its powers caused a considerable flutter of concern. Those who might be prospective users had visions of profitable applications to increase production and lower costs, with the disturbing thought of revisions of technique. Those who sold cutting steels recognized a new competitor that would make a doubling of their efforts necessary. Those who built machine tools feared the possibility of completely redesigning their machines in order to make the most profitable use of the new cutting substance. The situation was one which demanded instant and intelligent action, and under the A.S.M.E. special research committee on the cutting of metals a subcommittee on tungsten-carbide cutting materials was formed. This subcommittee has made several reports to the Society, and many papers relating to the material have been presented. Research on the new material in shop and laboratory is under way.

Mr. DuBrul has been urging industry for some time to cooperate in a research effort which will bring out the facts about tungsten carbide and its application that every one is anxious to have established. He drew attention to the cooperative researches that other industries have sponsored, and indicated the benefits that have been derived from them.

It seems unlikely, at present at least, that the industry will enter upon the intensive and expensive program that Mr. DuBrul outlined in very general terms. Some of his hearers came to the defense of the machine-tool builders and users and pointed out the great strides that had been made as was shown by the papers and reports which had been presented at that meeting. Actual experience in the shops is a research of a very practical nature, and with adequate facilities for discussing the results and placing them before those interested a very practical purpose is served. The efforts of the subcommittee as reported by Frank C. Spencer are to be continued. It may be said that already they have proved to be very helpful in many ways. One by-product has been the attention that has been called to the important subject of cutting tools. It has been reported to the subcommittee that the very fact that it was asking for information requiring the maintenance of carefully collected records was in itself a source of revelation to some shop managers who were finding in this routine important facts of value to them.

The discussion brought out many interesting sidelights from experiences of users of tungsten carbide. It was reported, for instance, that the ability to machine hard spots in castings was not always an unmixed blessing. While cutting piston rings with ordinary tools the hard spots were easily disclosed; in using tungsten-carbide tools they were not, with the result that the rings passed to final stages of manufacture before heat treatment showed the imperfections. That there is a field for tungsten carbide and for other types of tools was also brought out, and many failures of the material were explained by recognizing that it had its peculiarities and could not be used as steels would be. Taken all in all, the symposium was a very successful one, and highly gratifying as indicating the leadership taken by the A.S.M.E. in an important subject of interest to the machine-tool industry. With the tradition of its formation and early history and the classic investigations of Fred W. Taylor in the art of cutting metals as part of the A.S.M.E. literature, the present-day activities carried out under the sponsorship of the Society are in harmony. At the meeting of the Committee on the Cutting of Metals which followed the symposium, the subcommittee on tungsten carbide was requested to continue its work and was highly commended for the progress it had made. It was pointed out that a correlation of research programs was needed, and it was suggested that a meeting be arranged at which the cutting of metals by tungsten carbide, stellite, and tool steel might be compared. A program of cutting-fluid tests was also laid out.

It is impossible in this brief account to call attention to all of the excellent papers or to comment on all of the discussion. By virtue of the very excellent manner in which it was presented, the paper by Prof. H. F. Moore in which he reported on tests of the resistance to repeated pressure of forged, riveted, and welded boiler shells should be noted. It is unfortunate that all prospective authors could not have heard this presentation. It demonstrated how effectively such a subject may be presented, and showed that the writing of a paper for publication and its presentation at a meeting of engineers are entirely different methods of handling the same subject-matter. Professor Moore's familiarity with what he had to say made it possible for him to say it without hesitation and to present the essentials in a clear and logical way. He made use of lantern slides to illustrate his talk, and showed a proper realization that he was speaking on a subject which was beset with pitfalls for the unwary by reiterating at frequent intervals that his remarks and deductions applied to the conditions of repeated stress that were a feature of his tests, and not to conditions that might exist in boilers in operation where many more factors would necessarily have to be considered. Such an ably presented paper on such a timely subject deserved a more extensive discussion than followed it. It would have been interesting and profitable to have heard the proponents of these types of boiler construction air their doubts and beliefs, even if they might have been drawn away from the strict letter of the subject under discussion.

Engineers Should Lead in the Discussion of Economic and Social Problems

An example of this sort of discussion was afforded by the interesting session of the Management Division, in which the relative merits of the large and the small plant were considered. A. B. Reynders, works manager of the Westinghouse Electric and Manufacturing Company, Springfield, Mass., showed how a large plant might still retain the advantages of a small one and at the same time enjoy the advantages which went with its size. Col. Crosby Field was for the small plant, first, last, and all the time. The subject was a broad one and gave ample opportunity for an interchange of experiences and a free expression of opinion, not only by the principals but by the audience. Banker management and the ways of accountants came in for the usual expressions of disapprobation. Economic and social problems were touched upon. The latent ability evident from the remarks of several speakers demands that it be utilized by the Society in the discussion of such problems in a series of symposia on the humanitarian aspects of industrialization. Engineers should find the courage and opportunity to become leaders in this field. They have the necessary background of practical experience in the conduct of great industrial enterprises, and there was evidence at Detroit that they are not lacking in philosophical ability. After all, industrialism is a means to an end and a phase in societal evolution, and out of it may come some important and permanent contributions to the good life.

New Data on Comparative Boiler Performance

The Power Division was justly proud of the papers it sponsored at Detroit. It is some time since the Society has received such a complete set of data on boiler performance as is contained in the paper by Frank G. Philo, superintendent of steam generation of the Southern California Edison Company, Los Angeles, Calif. Mr. Philo's paper was on the comparative performance of a large boiler using oil and natural-gas fuels. Because of the widespread extension of natural-gas transmission lines and the increasing use of oil and natural gas in industrial and central-station plants, the data obtained by Mr. Philo should be of great interest and value. It is interesting to note that as a young man just out of college Mr. Philo participated in the

famous Delray tests reported to the A.S.M.E. by Dr. Jacobus in 1911. His own data were secured with the same care and accuracy that marked those earlier tests, and were presented in the form of curves. The Publication Committee has been successful in persuading Mr. Philo to present the actual data from which the curves were drawn, and these will be published with the original paper in the Transactions of the Power Division.

Another important set of data was reported by A. E. Grunert, efficiency engineer of the Commonwealth Edison Company of Chicago. Mr. Grunert's data were on the comparative performance of a pulverized-coal-fired boiler using the bin system and the unit system of firing. The data were presented without conclusions. A simple table summarizing the final results of the two systems and comparing them to other systems of combustion at the same station is quoted below.

	18 stokers	No. 22, bin system	No. 22, unit system	Another type, unit system
Period covered	93 mos.	24 mos.	11 mos.	26 mos.
Total cost in dollars per 1,000,000 B.t.u. delivered, with a coal cost of $18 per 100,000,000 B.t.u.	0.26847[a]	0.25374[b]	0.26258[b]	0.26216
Evaporative efficiency, per cent	77.4	83.35	83.7	81.1[c]
Auxiliary power, kw-hr. per ton	13.56	55.33	51.31	54.41

[a] Unusual expenses incurred by outages, maintenance, and renewal of all economizers included.
[b] Unusual expenses cited in paper included.
[c] Records of the last few months indicate that rehabilitations have improved performance.

THE SOCIETY'S CONSTRUCTIVE WORK COORDINATING RESEARCH

An example of the constructive work of the A.S.M.E. in coordinating research work on pressing problems is found in the papers read at the sessions devoted to the properties of metals at elevated temperatures, boiler-feedwater studies, and springs. It was particularly appropriate to devote a session to the properties of metals research, since so much of this work is going on in and about Detroit. Engineers and manufacturers are loath to proceed with the design of power stations using high degrees of superheat without more accurate data on the effects that elevated temperatures have on the material from which boilers and pipe lines are constructed. One such effect is that of creep, and while in certain applications deformations of appreciable magnitude are permissible, in others they are not, as, for instance, in turbine manufacture. One of the papers described an apparatus developed at the University of Michigan which is capable of measuring elongation to 2.8 millionths of an inch on a two-inch gage length. Another paper dealt with the flow characteristics of some special Fe-Ni-Cr alloys and some steels at elevated temperatures, and a third showed the effect on the flow characteristics of some lead cable sheath having different quantities of antimony in the lead.

At the boiler-feedwater session a method of determining the purity of steam and of supplies of water used for boiler-feed purposes and the concentration of boiler and evaporator water by measuring the electrical conductance was described, and studies of fractures in boiler metal due to known causes were presented. At the session on mechanical springs, Professor Sayre presented the sixth progress report of the special research committee, and A. M. Wahl reported some further research on helical springs, an extension of the work contained in his paper at the 1928 Annual Meeting, for which he was awarded a prize.

Of the many other excellent papers read at the sessions devoted to applied mechanics, machine-shop practice, pulp and paper, wood industries, aeronautics, and education and training for the industries, space does not permit adequate mention. Those who were fortunate enough to attend the sessions at which these papers were discussed have appraised their value, and others will find them in due time in the Transactions of the Divisions that sponsored them.

Research and Standardization

MANY committees working on research and standardization projects performed important work at the Detroit meeting, some of which will be reported later.

Mention has already been made of the Subcommittee on Tungsten Carbide Cutting Materials. The Research Committee on Heavy-Duty Anti-Friction bearings, which has raised money to employ a man working under Prof. W. Trinks to obtain from the steel companies data on load conditions, roll pressures, speeds, etc., of rolling-mill machinery in order to determine where anti-friction bearings are applicable, discussed the progress of the work and a program for future action. The Fluid Meters Committee released for publication in the near future a revision of Part 1—on Theory and Application—of its report originally published in 1924. This will be the third edition of this part of the report. Parts 2 and 3 (Description of Meters and Influence of Installation) were discussed in manuscript form. It is expected that they will be released for publication at an early date. New officers of the Research Committee on Mechanical Springs were announced at a meeting of this committee, where the work being done under the direction of Mortimer F. Sayre at Union College and D. J. McAdams, Jr., at the U. S. Naval Engineering Experiment Station was discussed.

Sixteen standardization committees met, with approximately 150 committee members in attendance. Three new subcommittees to develop small tools and machine-tool elements were organized. The Subcommittees on Oil Piping and Power Piping discussed the preliminary proposals that they had distributed for criticism and comment prior to the meeting. Subcommittee No. 2, on Wrench-Head Bolts and Nuts, discussed the proposed revision of the present American standard. It is expected that the proposed revision will be ready for distribution in the near future.

Aeronautic Meeting at Dayton

INTEREST in aeronautics is becoming less associated with its novel and spectacular aspects as a hazardous sport, and more with the hard facts of commercialization and rationalization. The exploits of skilled pilots still cause a thrill because most of us are land-bound folk, but we are forced to admit that the number and character of persons and organizations at present interested in the industry demand our giving it serious consideration. This was not so a dozen years ago.

When the War, which had demonstrated the military value of aeronautics, ceased and thoughts turned to peace and a resumption of normal conditions, few persons took aeronautics seriously. Without the support of the Government, through the Army and Navy air services, the Department of Commerce, the air mail, the laboratories and flying fields, and the National Advisory Committee for Aeronautics, progress would have been intolerably slow and commercial aviation would have languished. While aviation was thus in the doldrums, a few members of the A.S.M.E. convinced the Council of the Society that the engineering problems of aerial flight should receive sympathetic support, and as a result a Professional Division devoted to aeronautics was formed. From modest but enthusiastic beginnings the Division developed to a point where, in 1927, it staged its first national meeting at Buffalo, at which seven technical papers were presented. At the conclusion of the first ten years of its existence the Aeronautic Division of the A.S.M.E. has held its fourth national

meeting at Dayton, Ohio, May 19 to 22, an appropriate location, inasmuch as Major E. E. Aldrin, the organizing secretary and present chairman of the Division, had been stationed at McCook Field when the Division was organized in 1920. The facilities of Wright Field, and the cooperation of the Dayton Section of the A.S.M.E. and the Government departments interested in aviation, proved to be an excellent combination.

The twenty-six technical papers presented at Dayton demonstrated the diversity of the problems now confronting the aeronautical industry and the rapid changes that have come to it during the ten years of the Division's existence. They covered not only such technical aspects as the mechanics of design, but also the more general economic problems involved in production and transportation. They testified to the progress being made in the theory of airplane design and to the work being done in the field of materials of construction. A simple list of some of the subjects discussed is suggestive of the breadth of interest: Fields of usefulness of airplane and airship, reduction of production costs, metal construction, wing trussing, engineering organization, fuel and oil problems, superchargers, practical performance calculations, control at low speeds, airscrew losses, silencing, fire hazard, light-weight alloys, economics of air transport, instruments for "blind flying," transatlantic seaplanes, engine vibration, and trends of development of the industry. The authors represented Germany, France, and Italy, the United States Department of Commerce, and the staff at Wright Field, as well as the industries, educational institutions, and private aeronautical interests. Such international contacts are most valuable in an industry as young as aviation is, and reflect great credit upon the committees that arranged them.

The impressions left by the Dayton meeting are of the varied interests in aviation, of the contributions made on behalf of this new industry that are of equal benefit to others, of a serious-minded confidence in its ultimate value to human progress, of a realization that success will come only after its problems are attacked and solved in the spirit of the scientific method. Makeshifts in the way of inadequately suited materials will not do, nor will it do to rely only on the ability of the exceptional pilot, on the exceptional designer, and on the exceptional combination of circumstances. Mechanical perfection, safety and reliability, economical production and operation, extension of the field of application, are the goals toward which the authors of these papers and their associates are striving in their study of mechanics, aerodynamics, economics of production and transportation, fire protection, instruments for blind flying, and transatlantic planes. They have high ideals and a tremendous and undeveloped field. By bringing such men together and offering them an opportunity to discuss their problems with one another, as was done at Dayton, the Aeronautic Division is performing a splendid service.

Conference of Canadian Provincial Boiler Inspectors

THE Triennial Conference of Provincial Boiler Inspectors of Canada was held in Calgary, Alberta, on May 5 to 12, for the purpose of considering revisions, additions, and changes to the Canadian Interprovincial Boiler Regulations. The Province of Alberta served as host to the conference for this meeting, Messrs. Walter Smitten, Commissioner of Labor of the Province, and F. W. Hobson, Chief Boiler Inspector, officiating. The meetings of the conference were held in the old Provincial court house, now the Land Title office, which was the first masonry structure in Alberta.

Those in attendance at the Conference were as follows:

D. M. MEDCALF, Chairman, Ontario
T. INGLIS, Secretary, Saskatchewan
A. S. BENNETT, British Columbia
F. W. HOBSON, Alberta
R. A. STEWART, Manitoba
N. S. WALSH, Quebec
} Representing Six Provinces

C. W. OBERT, Representing the A.S.M.E. Boiler Code Committee.

The power-boiler, heating-boiler, and unfired-pressure-vessel sections of the Canadian Interprovincial Boiler Regulations were reviewed paragraph by paragraph, with a view to correcting and bringing up to date whatever features past experience had shown needed revision. Among the subjects discussed were such items as bracing and staying of flat surfaces, dished-head construction, furnace construction, factors of safety, and fittings and attachments, including safety-valve requirements. One of the most important features of the conference was the discussion on fittings and attachments in which there had been a lack of uniformity of practice. As a result, many of the features of the rules in which the different provinces were at variance were adjusted.

Due consideration was paid to low-pressure heating boilers and to unfired pressure vessels, and here also efforts were made to place the rules on a basis where the various provincial inspectors could agree on uniformity of enforcement. Particularly in connection with applications of welding were such studies of importance and value, in view of the greatly increased use of welded construction. The members of the conference agreed that the use of welded construction is advancing at a rate that commands their serious attention and thought. For this reason the developments in both Europe and the U.S.A. were carefully studied. The recent revisions in the A.S.M.E. Unfired Pressure Vessel Code and also the proposed A.S.M.E. specifications for welded boiler drums were seriously considered. As a result, a number of important modifications of these two sections of the Interprovincial Boiler Regulations were agreed upon.

At the close of the conference, it was the consensus of opinion of those present that the meeting had been highly beneficial in eliminating differences of opinion and establishing uniformity of viewpoint among the various provinces, upon all matters in which they are mutually interested. It was the belief that features of the confusion that have existed in the boiler and pressure-vessel industry due to variations in practice in the different provinces, will now be eliminated. It was also a matter of satisfaction to the members of the conference to know that revisions have been authorized in the Interprovincial Regulations which will bring their rules up to date and coordinate their practice with the best that is known in Europe and the U. S. A.

At the close of the conference, adjournment was taken for a period of two years, which was in recognition of the fact that the Conference had been beneficial to the members. It was the hope of the members that the Conference could be established on a biennial basis in the future, or perhaps on an annual one. The next meeting was scheduled to be held at Montreal in the spring of 1932. D. M. Medcalf was reelected chairman of the Conference and T. Inglis, secretary.

During the conference the members enjoyed interesting side trips to the Turner Valley oil field, and to Banff in the Canadian Rockies. At Turner Valley, the remarkable petroleum and natural-gas wells were inspected, and the very unusual features of this rich and profitable oil development were observed. En route to Banff, the new Ghost River water-power development about forty miles west of Calgary was visited. The visit to Banff was a week-end trip, where the delegates inspected the magnificent Banff Springs Hotel, and were shown the beauties of this unusual mountain resort with its glacier-covered mountains, mountain lakes, canyons, and numerous hot springs.

C. W. OBERT.

Book Reviews and Library Notes

THE Library is a cooperative activity of the A.S.C.E., the A.I.M.E., the A.S.M.E., and the A.I.E.E. It is administered by the Engineering Foundation, Inc., as a public reference library of engineering and the allied sciences. It contains 150,000 volumes and pamphlets and receives currently most of the important periodicals in its field. It is housed in the Engineering Societies Building, 29 West 39th St., New York, N. Y. In order to place its resources at the disposal of those unable to visit it in person, the Library is prepared to furnish lists of references on engineering subjects, copies of translations of articles, and similar assistance. Charges sufficient to cover the cost of this work are made.

The Library maintains a collection of modern technical books which may be rented by members residing in North America. A rental of five cents a day, plus transportation, is charged. In asking for information, letters should be made as definite as possible, so that the investigator may understand clearly what is desired.

A German Treatise on Heat Engines

WÄRMEKRAFT UND WÄRMEARBEITSMASCHINEN. By A. Loschge. Akademische Verlagsgesellschaft, Leipzig, 1929. Cloth, 362 pp., 7 × 9½, 270 illustrations.

REVIEWED BY N. ARTSAY[1]

THIS book is a part of the set, "Handbuch der Experimentalphysik," edited by W. Wien and F. Harms, which contains, among its contributors, such names as those of Föppl, Knoblauch, Kohlrausch, Laue, Lenz, Prandtl, and other experts in different fields. Its purpose is the general exposition of the theoretical principles of heat engines for non-specialists, and it suits the purpose admirably, provided the reader is well grounded in fundamentals. The text is well condensed, the calculus is avoided, and the work offers much interesting technical reading for graduate engineers wishing to brush up on their acquired and scattered knowledge. Brought up to the last word in the theory of thermal power generation, the book fills the yet vaguely felt need of bringing back the fundamentals so easily forgotten in the narrow paths of practical work. In short, and tritely, the contents are what a well-educated engineer should know about heat engines in general, outside of his special line.

The treatment is theoretical—nowhere in the text are practical operation and its troubles touched upon, nor the materials entering into construction described. The thermal properties of working fluids are given only as instances, and steam charts are absent. In conjunction with other volumes of the "Handbuch" the work of Professor Loschge will be useful in the theoretical discussion of heat-engine problems, and taken by itself it has a distinct educational value in developing the rudiments of a rational theoretical outlook.

Work Routing in Production

WORK ROUTING IN PRODUCTION. By John Younger. The Ronald Press Company, New York, 1930. Cloth, 5¾ × 8⅜ in., 115 pp., illus., $2.50.

REVIEWED BY WM. S. AYARS[2]

PROFESSOR Younger has written a very readable and useful little book, and has really covered far more ground than suggested by the title. To an experienced industrial engineer, much of the matter appears very obvious; but, as he states in his preface, "The book has been written for two groups of readers: production executives and students of industrial engineering." One who has had considerable experience in teaching industrial-engineering courses knows only too well how appalling is the ignorance of the average undergraduate on matters that, to the experienced engineer, are almost axiomatic. And as to the other class referred to, production executives, it must not be forgotten that for every large, outstanding plant we hear about, there are hundreds struggling along at a hit-or-miss pace, perfectly unaware of dozens of ways in which they might cut costs and decrease waste.

The late Frank B. Gillbreth once stated to a group of engineers that the most astounding discovery usually made when scientific time and motion studies were first introduced into any factory, was not that individuals rated and paid the same varied slightly in output and personal efficiency, but that they varied several hundred per cent. And this frequently happened, not in small and struggling establishments, but in large, prosperous, and apparently well-run ones. It is well to bear in mind, then, that many a production executive, even today, is quite as much in need of the elementary and the obvious as is the undergraduate student of industrial engineering.

Like nearly all books dealing with production problems, practically all data used are derived from the metal trades, and principally from one outstanding subdivision, the automobile industry. It might be well if future writers of books along similar lines would draw more fully on the non-metallic industries, not only for the sake of variety, but because many such industries today are sorely in need of their advice and instruction.

The book should prove very useful as a text for all engineering students, and for such a purpose it is very well planned and executed. The questions at the end of each chapter should be helpful and stimulating, both to student and instructor. One interesting subject introduced ought to be of value in shops where otherwise good machines are in danger of becoming obsolete or inadequate: the increasing use of special fixtures and attachments. The writer has personally seen this carried out with great profit in the textile industry, and there is no reason why it cannot be applied equally well in others. A few hundred dollars spent on special fixtures, tools, and attachments may very easily save a $5000 machine from the second-hand dealer or the junkman. It is a subject not often mentioned by technical writers, and, quite naturally, is carefully avoided by the builders of production machines in practically every one of the industries.

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[2] Principal Assistant Engineer to Geo. A. Orrok, Consulting Engineer, New York, N. Y. Mem. A.S.M.E.

Industrial Heat Transfer

DER INDUSTRIELLE WÄRMEÜBERGANG (INDUSTRIAL HEAT TRANSFER). By A. Schack. Verlag Stahleisen, G.m.b.H., Düsseldorf, Germany, 1929. Cloth, 6 × 8 in., 411 pp., 41 diagrams and 37 tables, 18.5 marks.

REVIEWED BY W. H. MCADAMS[3]

AS STATED in the preface, this book is intended primarily for the practical engineer interested in heat transmission. The text deals with heat flow by conduction, by convection, and by radiation from solid to solid and from gas to solid. The development is logical, starting with the basic mathematics, and the presentation is clear. However, the treatment is such that those not interested in the derivation of equations can readily apply the results. Thus, the text contains a convenient summary of the recommended formulas and tables of physical data, and a number of illustrative problems are solved. In some cases the ranges of data supporting the formulas are not stated in the summary of equations, but are given in the text. Where it was not found possible to represent the data by simple equations, the results are presented in the form of curves.

While the principle of dimensional homogeneity is considered and used as a guide in deriving formulas to represent test data for heat transfer by convection, the recommended formulas contain the relatively few factors justified by the data employed, rather than the large number found in many equations in the literature. Thus, the equations recommended for convection do not involve the physical properties of the fluids, but are expressed in terms of factors such as mass velocity, diameter, temperature, and temperature difference. The book contains few data on the transfer of sensible heat between tubes and liquids other than water. Considerable space is devoted to heat transfer in blast-furnace stoves, and to similar problems.

The text contains an excellent and comprehensive review of the work of various German investigators, particularly of those connected with the "Wärmestelle des Vereins deutscher Eisenhüttenleute." Occasional reference is made to work in England and in the United States. Of the latter, 1924 references were the most recent noted, although important references prior to 1924 are omitted. Too little space is devoted to the work of Reynolds, Stanton, and Prandtl, and no reference was found to the published work of Carrier, Wilson, King, Taylor, Davis, Royds, Rice, McMillan, Lewis, Ward and Voss, Nichols, Chappell, Sherwood, Haslam and Hottel, Morris and Whitman, and Cox. Similarly, books on heat transmission written in England and the United States are incomplete with respect to important references in German. It seems unfortunate that writers on the Continent and in English-speaking countries are so out of touch with each other.

Schack will be remembered as the pioneer in the application of the data of physicists to the problem of non-luminous gas radiation. This book gives a comprehensive treatment of gas radiation, a topic rarely treated in textbooks. This section includes new material on the radiation from water vapor, which for thick gas layers indicates a substantial increase over the old values. The author gives the impression that the representation of total gas radiation, as a function of temperature and the product of gas concentration by thickness of gas layer, is an approximation which neglects shape factors for the radiations from the various bands, whereas Hottel has shown that these factors may all be brought very close to unity by a proper choice of "effective" thickness of the gas layer. The latter treatment becomes particularly important for a number of common shapes in which the gas-layer thickness is small.

Radiation from solid to solid is not treated with a completeness comparable to that of other sections of the book.

In spite of the omissions cited, the book is a valuable contribution and should be in the library of those engineers specializing in heat transmission.

[3] Associate Professor of Chemical Engineering, Massachusetts Institute of Technology, Cambridge, Mass. Mem. A.S.M.E.

Books Received in the Library

EISENGUSS IN DAUERFORMEN. By Friedrich Janssen. Julius Springer, Berlin, 1930. Paper, 7 × 10 in., 92 pp., illus., diagrams, tables, 10.50 r.m.

Reviews the development and prospects of permanent molds for iron castings. The historical development of the process, the casting machines and molds, and the metallurgical and engineering problems encountered are discussed.

HISTORY OF SCIENCE AND ITS RELATIONS WITH PHILOSOPHY AND RELIGION. By William Cecil Dampier-Whetham. Macmillan Co., New York, 1929. Cloth, 6 × 9 in., 514 pp., $6.

This is the best attempt to tell the general story of science that has appeared since Whewell wrote his books on the history and philosophy of the inductive sciences, nearly one hundred years ago. In ten very readable chapters we have not a detailed study of any one period or subject, but a complete outline of the development of scientific thought from the ancient world down to the present time. The inner meaning of science and its bearing on philosophy and religion are admirably emphasized.

PRACTICAL MECHANICS AND STRENGTH OF MATERIALS. By Charles W. Leigh and John F. Mangold. Second edition. McGraw-Hill Book Co., New York, 1930. Cloth, 5 × 8 in., 420 pp., illus., diagrams, $2.75.

A textbook for night schools and vocational schools, covering those principles that are essential for the practical man, and using only elementary mathematics. Based on experience as teachers in the night school of the Armour Institute of Technology.

PRACTICAL WIND BRACING. By Harry E. Schneider. Published by the author, Buffalo, N. Y., 1930. Cloth, 6 × 9 in., 192 pp., diagrams, $3.

The aim of this book is to provide a simple method which will enable any engineer with a knowledge of structural design and the theory of beam flexures to design the wind bracing for any type of high building. The author uses the four usual methods: the cantilever, portal, continuous portal, and the Smith; and solves a number of problems by each. He describes several short cuts that simplify the calculation of wind stresses and shorten greatly the time required to design the bracing.

PRINCIPLES OF IRON FOUNDING. By Richard Moldenke. Second edition. McGraw-Hill Book Co., New York, 1930. Cloth, 6 × 9 in., 654 pp., illus., tables, $6.

Dr. Moldenke's presentation of the principles underlying the processes involved in founding is admirably designed to meet the needs of practical foundrymen who wish to be informed on foundry metallurgy. This new edition has been extensively revised and enlarged to include the changes resulting from the advent of "high-test" cast-iron.

PRIOFORM-HANDBUCH. By Deutsche Prioform Werke Bohlander & Co., Köln. Second edition. Julius Springer, Berlin, 1930. Cloth, 5 × 7 in., 283 pp., tables, 15 r.m.

A handbook for engineers interested in heat insulation, which contains a concise presentation of the principles of the subject and of the application of theory to practical problems. About one-half of the book is devoted to physical and chemical tables of use in the design and use of insulating materials.

Synopses of A.S.M.E. Transactions Papers

THE papers abstracted on this and following page appear in the current issues of Aeronautical Engineering, Management, and Printing Industries sections of A.S.M.E. Transactions. These sections have been sent to all who registered in the similarly named Divisions. Other sections are in the course of preparation and will be announced when completed, in later issues of "Mechanical Engineering."

AERONAUTICAL ENGINEERING PAPERS

PROGRESS IN AERONAUTICS. [Paper No. AER-52-1]

This report, contributed by the A.S.M.E. Aeronautic Division, reviews the progress made in the aviation field during 1929. It deals successively with power plants, airplane design and construction, aerodynamics, air transport, naval and military aviation, airships, and airports. Among the tables included are one on airplane engines for which approved-type certificates were issued in 1929, another giving air-transport mileage and traffic statistics, and a third on airports and landing fields in the United States.

THE THEORY OF THE AUTOGIRO. By Juan de la Cierva. [Paper No. AER-52-2]

The author, realizing the fundamental limitations of the ordinary airplane, has worked for years to produce a new system of flying. Passing the helicopter and ornithopter stage, a machine was devised with articulating blades that could flap freely, the dissymmetry of the reactions on opposite blades being thereby overcome.

THE PROBLEM OF CATAPULTING AIRCRAFT FROM COMMERCIAL VESSELS. By Lieut. Wm. M. Fellers. [Paper No. AER-52-3]

After describing the catapult mechanism and the launching car, the author discusses the development of catapult launching by the U. S. Navy. Following this he outlines the several steps in launching a plane, stating the precautions which should be taken. In conclusion he discusses the possibilities of a ship-to-shore plane service, using catapults. It is his belief that the same mechanisms employed successfully in the Navy can be transferred almost intact to any commercial vessel, and that planes can be launched from shipboard with a degree of regularity and safety compatible with commercial operation.

RECENT DEVELOPMENTS IN AIRCRAFT ENGINES. By John H. Geisse. [Paper No. AER-52-4]

Improvements in engine design for airplanes during the year have been gradual. Production facilities now exceed the demand and developments should come more rapidly. There has been a trend during the year toward the "in-line" or air-cooled types of engines. However, the radial type still possesses a number of advantages. Manifolding in radial engines is quite a problem due to the impossibility of getting symmetry except in nine-cylinder types where three three-way manifolds may be used.

Cylinder construction with a steel sleeve having machined cooling fins and a cast-aluminum head is accepted quite generally, and there is a trend toward the use of heat-treated alloys for the crankcase. Many interesting developments in the Diesel types of airplane engines can be expected.

THE AIRCRAFT DIESEL ENGINE. By Leigh M. Griffith and Edward T. Vincent. [Paper No. AER-52-5]

In this paper the authors present information to show that the Diesel or fuel-injection engine in some of its modified forms is well adapted to the requirements of airplane and airship propulsion. They believe that its first and most important commercial application will be in relatively large units on large aircraft and that increased fuel economy, both as to weight and cost, will be an important factor in the progress of commercial air transportation. They consider that the greatly reduced fire hazard will be an important factor in the development of quantity air transport of passengers, and that the absence of radio interference will greatly simplify the problems of navigation and communication. The potential advantages of two-stroke-cycle operation will be realized in the Diesel engine. In large airplanes from one to three engines of large size will be used, and these will be mounted and enclosed so as to allow of attendance during flight. Such engines will be fluid-cooled, either by liquid circulation or evaporation. The service reliability of the Diesel, they believe, will exceed that of the carbureted, air-cooled engines inaccessibly mounted, and the problems of weight and cost are less serious than are generally supposed, and will soon be solved commercially.

FACTORS IN THE DESIGN OF COMMERCIAL AIRPLANES. By Charles Talbot Porter. [Paper No. AER-52-6]

A steady and profitable market may be expected for existing equipment in remote and inaccessible places, where other forms of transportation are not available, but the real problem is to make the air transport compete successfully with the extra-fare trains. The real commodity that is being sold in transportation, and the factors involved, are speed, comfort, and cost, assuming of course that safety and reliability have been demonstrated. The combination of these three factors must equal that of the fast train. The cost of air travel is of necessity high; therefore the speed-comfort combination must exceed that of the railroads. In general, the comfort of the train at least equals that of the airplane, so the latter must be sold on the speed factor alone, without sacrifice of a certain minimum requirement for comfort and at a cost that is justified by the increase in speed.

Existing air transports have a high speed of 135 to 145 miles per hour, a capacity of ten to twelve passengers, and a power output of 100 hp. per passenger. The author advocates the development of a 30- to 40-passenger airplane that will equal present speed requirements with a reduction of power to 50 to 60 hp. per passenger. To obtain this result he advocates abandoning direct-drive air-cooled radial engines and replacing them by geared engines, air-cooled or liquid-cooled, placed preferably inside the wing, with a remote drive to the propellers.

SEAPLANE DESIGN. By T. P. Wright and G. A. Luburg. [Paper No. AER-52-7]

The design of the seaplane is given in detail, and the advantages of its use are described. The seaplane can generally find a landing place nearer to the center of large cities than can the land airplane. The flying boat, it is predicted, will ultimately be the method of air travel across the oceans. The market for the flying boat and the amphibian is waiting for development by the manufacturer and operator.

MANAGEMENT PAPERS

NATIONAL ELIMINATION-OF-WASTE CAMPAIGN. By C. B. Auel. [Paper No. MAN-51-13]

Campaigns to eliminate waste are not cure-alls, but they strongly supplement the regular efforts of the management. The steps preparatory to such a campaign are decided, the supervisory force is coached so that their plans are crystallized, the workers are made to understand the purpose, and then exhibits are placed about the plant showing concrete cases of waste and the cost in time and money. In the plant where the campaign described was carried on, the saving directly attributable to the effort was $50,000. A general review of the national campaign is given, together with the special effort in certain plants.

ORGANIZING A WAR ON WASTE. By Raymond Chalmers and W. E. Roe. [Paper No. MAN-51-14]

On April 24, 1929, the superintendents of the Oakland Motor Car Company decided to conduct an elimination-of-waste campaign. The campaign was carried on for two weeks beginning May 6 and it is estimated that the saving which will result will amount to $542,000. The total cost was $16,000.

In preparing for the campaign, available data were collected from other companies which had conducted similar campaigns. The procedure was then outlined, three major divisions being organized to conduct the drive—publicity, exhibits, and suggestions. Since the campaign the original procedure has been slightly revised, improving in accordance with experience. The description of the procedure given in the paper contains these revisions and should be of value not only to companies wishing to carry on an extensive campaign, but also to smaller companies which may adapt various parts of it to meet their individual plant needs.

APPRENTICESHIP IN THE RUBBER INDUSTRY. By C. C. Slusser. [Paper No. MAN-51-15]

In this paper the author describes the apprenticeship training courses used by the Goodyear Tire and Rubber Company. The training is of four classes—the production squadron, the engineering squadron, the Goodyear Industrial University Training Course, and the apprentice machinist course. Candidates are selected by means of an intelligence test, a personal interview, and a physical examination.

The production squadron provides production men for departments where extra help is needed. The engineering squadron prepares men for positions as foremen, inspectors, and staff assistants. The Industrial University Training group gives instruction to high-school graduates who wish to enter staff work, but require additional training. The apprentice machinist course trains men to be skilled mechanics.

PRINTING INDUSTRIES PAPERS

INTERNATIONAL CONFERENCE OF THE TECHNICAL EXPERTS IN THE PRINTING INDUSTRY ON THE NEED FOR RESEARCH. [Paper No. PI-51-6]

There was held on November 7 and 8, 1929, at the Carnegie Institute of Technology in Pittsburgh, Pa., a world congress of the key men in the printing and allied industries to consider the need for coordinated and cooperative research in the endeavor to aid in finding a solution for some of the problems of the trade. Twenty-six national and international organizations participated in the conference, sending their delegates and other members. There were twenty-one addresses on the program, each one delivered by the acknowledged expert in his field. These addresses covered every phase of the industry that was subject to the benefit of research, with also several addresses by engineers who could explain the aid that other industries had received from research. This conference, the first in the printing industry in which there was engineering participation, was perhaps the most notable ever held in its history, for it was general and inclusive in the representation of the interests in its field, and called forth the leading figures of all its branches. The addresses and engineering talks were as follows:

Purpose in Calling a Conference of the Technical Experts in the Printing Industry, by Edward Pierce Hulse.

Larger Use of Engineering in Printing Production Is Predicted, by George R. Keller.

A Plan for a Printing Research Foundation, by Arthur C. Jewett.

The Necessity for Research in the Printing Industry, by George H. Carter.

The Evolution of the German Printing Trade, by Franz Helmberger.

What British Printers Are Doing to Encourage Research, by John R. Riddell.

Canadian Bureau Seeks Out the Latest Machinery and Processes, by John Munro.

A Meeting to Consider Only the Practical and Technical Details of Printing Operations, by John Clyde Oswald.

The Printing Industries Division Had Its Origin About Eight Years Ago, by William Clement Glass.

What the Bureau of Standards Has Done in Research for the Printing Industries, by Henry D. Hubbard.

How the Engineer Would Approach the Problem, by L. W. Wallace.

Research Problems in the Newspaper Printing Field, by John W. Park.

Research Problems in the General Printing Field, by George K. Hebb.

Conference Has Thrown Some Bright Light on the Graphic Arts, by Warren C. Browne.

Outstanding Points That Invite Research in Lithographic and Offset Printing, by George C. Van Vechten.

Research Problems in Lithographic Printing—The Lithographic Technical Foundation, by L. S. Hawkins.

Research Problems in Lithographic Printing and Machinery, by Thomas R. Jones.

Research Problems in Photo-Engraving, by William J. Wilkinson and Adolph Schuetz.

Research Problems in Electrotyping, by Hamilton Enterkin MacArthur.

What Research Can Do for the Bookbinding Industry, by Roy C. Baker and F. R. Blaylock.

Limitations of Standardization and Research in Ink Making, by Edwin M. Van Dyck and Dr. Walter W. Mock.

What Research Has Done in Paper Making and Using, by J. Newell Stephenson.

What Research Has Done in Type Metal, by Dr. G. W. Thompson.

The Key Men of the Industry Through Whom Research Will Have to Be Applied, by A. E. Giegengack.

The High Grade of the Prepared Papers, by Winfield S. Huson.

Accuracy in Printing-Press Construction, by J. R. Blaine.

Research Applying to the Relationship of the Impression and Plate Cylinders of Newspaper Printing Presses, by Theodore T. Ellis.

Practical Results From Humidity Control in a Modern Printing Plant, by Dr. J. Horace McFarland and Carl W. Davis.

Research—From the Operator's Standpoint, by Major George L. Berry and L. W. Claybourn.

Effect on Research and Production of Present Material-Handling Methods, by George E. Hagemann.

Progress in the Printing Industries, by Winfield S. Huson.

NOTE: Those who have not registered in the A.S.M.E. Aeronautics, Management, and Printing Industries Divisions whose papers are abstracted on this and the previous page, and who desire copies of any of these papers, may obtain them by using the form given below.

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AIR CONDITIONING

Research in. Along the Road of Controlled Indoor Atmosphere, P. West. Heat, Piping and Air Conditioning, vol. 2, no. 4, Apr. 1930, pp. 308–317, 6 figs. Discussion of research work by American Society of Heating and Ventilating Engineers, at Research Laboratory in conjunction with U. S. Bureau of Mines, and U. S. Bureau of Public Health; effective temperature chart and how to use it; practical standards for heating for humans not engaged in manual labor; theoretical standards of air conditioning; psychrometric charts; practical standards of ventilation; cooling for warm summer weather; ventilation of hospitals.

AIR PREHEATERS

Howden Ljungström. The Howden-Ljungström Air Preheater. World Power (Lond.), vol. 13, no. 74, Feb. 1930, pp. 189–190 and 193–195, 2 figs. Use of preheated air for combustion in relation to upkeep costs of stokers and furnace lining is discussed, and it is shown that, in modern power plants, it is possible to eliminate all difficulties due to increased furnace temperature; working principle of Howden-Ljunström air preheater.

AIRPLANE ENGINES

Design. Influence of Power-Plant Weight on Performance (Der Einfluss des Triebwerksgewichts auf die Flugleistungen), M. Schrenk. Luftfahrtforschung (Munich), vol. 6, no. 4, Feb. 14, 1930, pp. 92–95 and discussion) 95–96, 4 figs. In preceding article by Kamm (same issue, p. 87) development of engine is urged which is more reliable in operation, but, on the other hand necessarily heavier than most of those now used; present author, as airplane manufacturer, reports effect of such an engine on airplane performance, and suggests means and ways of overcoming disadvantages of heavy power plant.

Small Airplane-Engines, N. N. Tilley. Soc. Automotive Engrs.—Jl., vol. 26, no. 3, Mar. 1930, pp. 346–351 and (discussion) 351 and 371, 12 figs. Stating that requirements of airplane power plant are light weight, low fuel, and oil consumption, reliability and durability smooth and flexible operation and compactness, author discusses briefly how these are obtained; greater proportionate weight of accessories, foundry limitations and other considerations than loads and stresses tend to make small airplane engine heavier in proportion to horsepower than larger power plants, manufacturing cost being more important than maximum performance in power and weight.

Diesel. The Junkers Heavy-Oil Aero Engine. Engineering (Lond.), vol. 129, no. 3352, Apr. 11, 1930, pp. 471–473, 12 figs. on supp. plate. Engine incorporates valveless opposed-piston two-cycle arrangement associated with name of firm history of development of Junkers engines since 1914; detailed researches were undertaken with view to solving problems connected with operation and weight; in constructing fuel pump, Junkers made use of their experience with stationary engines; dynamical stresses on gearing were subject of exhaustive investigation.

The Packard Diesel Aircraft-Engine, L. M. Woolson. Soc. Automotive Engrs.—Jl., vol. 26, no. 4, Apr. 1930, pp. 431–442, and 449, 7 figs. Author describes many radical features of design that resulted in producing engine which operates at 2000 r.p.m. on domestic furnace oil, has compression ratio of 16:1, air compression of 500 lb. per sq. in., compression temperature of 1000 deg. fahr., fuel pressure of order of 6000 lb. per sq. in., develops 225 hp. at 1950 r.p.m. and weighs 2.26 lb. per rated horsepower.

Redrup-Lever. The Redrup-Lever Axial Engine. Aeroplane (Lond.), vol. 38, no. 7, Feb. 12, 1930, pp. 262 and 264, 5 figs. From point of view of aircraft designer, there is room for improvement in design of air-cooled engines; several solutions developed by Redrup Lever Engine Syndicate; description of axial engine.

Research. Thermodynamic Aspects of Aeronautical Research (Thermodynamische Aufgaben der Luftfahrtforschung), K. Loehner. Luftfahrtforschung (Munich), vol. 6, no. 4, Feb. 14, 1930, pp. 111–120, 8 figs. Thermodynamics of aircraft engines embraces phenomena occurring in gases due to special influences affecting these engines, such as heat transfer, and auxiliary equipment, such as blowers and exhaust-gas turbines; further development of aircraft Diesel is deemed desirable; results of thermotechnical measurements. Bibliography and table giving saturated-vapor temperatures of fuel mixtures and initial temperature for dry and moisture-containing air.

Vibrations. Vibrations in Airplane Power Plants (Die Schwingungen in Luftfahrzeug Triebwerkanlagen), K. Luerenkaum. Luftfahrtforschung (Munich), vol. 6, no. 4, Feb. 14, 1930, pp. 97–102 and (discussion) 109–110, 9 figs. Oscillations and dynamic stresses which are source of hazard to airplane power plant are studied, but without aid of numerical data, and with special reference to torsional vibrations, which are probably main cause of failures; means of reducing hazard of torsional vibrations are studied.

AIRPLANES

Autogiro. See AUTOGIROS.

Design. Design of Cantilever Wings (Zur Berechnung freitragender Fluegel), K. Friedrichs and T. v. Karman. Zeit. fuer Angewandte Mathematik und Mechanik (Berlin), vol. 9, no. 4, Apr. 1929, pp. 261–269, 4 figs. Theoretical mathematical analysis making use of Clapeyron equations; design of ribs to resist torsional stresses.

Theoretical and Experimental Study of Class of Profiles With Constant Center of Pressure (Etude théorique et expérimentale d' une classe de profils à centre de poussée constant), M. Risack. Service Technique de l' Aéronautique—Bul., (Brussels), no. 9, Mar. 1930, pp. 3–22, 10 figs. Résumé of mathematical wing theory; requirements for transforming of circle into customary wing profile; curves and data on wing profiles; some polar curves of bulletin no. 7, have been revised because use of standard wing in tunnel tests has reduced errors due to suspension of air foil.

Propellers, Variable-Pitch. Fuscaldo Metal Propeller Permits Pitch Variation During Flight (L'hélice métallique Fuscaldo à pas variable en vol). Aéronautique (Paris), vol. 12, no. 131, Apr. 1930, pp. 129–130, 5 figs.; see also description in Aérophile (Paris), vol. 38, no. 5–6, Mar. 15, 1930, pp. 92–93, 4 figs. Detailed description of design and functioning of mechanism; weight of one blade of three-bladed propeller from 100-hp. engine is 2 kg.

Shock Absorbers. Shock Tests on Compression Rubber Springing for Airplane Landing Gear (Stossversuche an Druckgummifederungen fuer Flugzeugfahrgestelle), K. Hohenemser. Zeit. fuer Flugtechnik und Motorluftschiffahrt (Munich), vol. 21, no. 6, Mar. 28, 1930, pp. 133–137, 15 figs. It is shown that compression rubber during deformation adheres rigidly to compression surfaces, based on which fact, suggestion for simplification of compression-rubber design is obtained; hysteresis is attributed to external and internal frictional forces; investigation of shock absorption by compression rubber.

AIRSHIPS

Mooring Masts. The St. Hubert Airship Mooring Tower. Engineer (Lond.), vol. 149, no. 3872, Mar. 28, 1930, pp. 358–359, 2 figs. Canadian tower is self-contained structure, anchored to concrete footings; at base there is two-story building, cruciform in shape, to house mooring winches, heating plant, etc.; it is octagonal structure 171 ft. high, surmounted by projects telescopic mooring arm to which nose of airship is attached; total height of tower to top of mooring arm is 205 ft.

ALLOYS

Aluminum. See ALUMINUM ALLOYS

Bearing Metals. See BEARING METALS.

Brass. See BRASS.

Chromium-Nickel. See CHROMIUM-NICKEL ALLOYS.

Copper. See COPPER ALLOYS.

Die-Casting. See BRASS.

Heat Treatment. Heavy-Metal Alloys Capable of Heat Treatment (Verguetbare Schwermetall-Legierungen), G. Masing. Zeit. fuer Metallkunde (Berlin), vol. 22, no. 3, Mar. 1930, pp. 90–94, 7 figs. Prospects of finding alloys which can be subjected to heat treatment are discussed; of greatest technical importance at

present time are Heusler and Corson alloys, and alloys containing beryllium; refining of copper-bearing iron alloys, carbon-iron alloys, and eutectoid disintegration of zinc-aluminum alloys.

Phosphor Bronze. See BEARING METALS.

Properties. Thermal Properties of Different Groups of Alloys (Die thermischen Eigenschaften verschiedener Legierungsgruppen), A. Schulze. Giesserei-Zeitung (Berlin), vol. 27, no. 7, Apr. 1, 1930, pp. 177–184, 23 figs. Thermal expansion (dilatometry) and its relation to constitution of alloys is discussed and method of investigation described; relations between heat conductivity and constitution; notes on magnetic properties of alloys and X-ray analysis by which fine structure of alloys is rendered visible.

ALUMINUM ALLOYS

Aluminum-Copper. Ultralumin (Ultralumin), F. Bollentrath. Luftfahrtforschung (Munich), vol. 6, no. 1, Dec. 12, 1929, pp. 18–32, 28 figs. Results of investigation made at Aerodynamic Institute of Technology on metal placed on market under trade name of Ultraluminum U II; it is aluminum-copper alloy, free from magnesium, strength of which can be increased by artificial aging; melting point, 645 deg. cent.; forging temperature, 460 to 480 deg.; heat-expansion coefficient, 0.000022; temperature resistance coefficient 0.00218; modulus of elasticity, 6900 to 7300 kg. per sq. mm.

Heat Treatment. Aluminum Alloys Capable of Heat Treatment (Vergueteare Aluminiumlegierungen), W. Fraenkel. Zeit. fuer Metallkunde (Berlin), vol. 22, no. 3, Mar. 1930, pp. 84–89, 15 figs. An example of simple alloy, aluminum with slight copper content, and its heat treatment are discussed; phenomena observed with treatment at ordinary, elevated, and fluctuating temperature; theory of treatment is discussed; main types of important aluminum alloys and their transformation to other and to more complicated systems are described.

AUTOGIROS

Theory of, Autogiro. Flight (Lond.), vol. 22, no. 14, Apr. 4, 1930, p. 391, 3 figs. Theory of autogiros; many engines may be used; Armstrong-Siddeley "Genet" or "Cirrus III" is advocated for privately owned machines; fuselage of normal construction; autogiro tests on 3000 mile flight without accidents.

AUTOMOBILE ENGINES

Combustion Chambers. Combustion Chamber Research, H. S. Glyde. Automobile Engr. (Lond.), vol. 20, no. 264, Feb. 1930, pp. 62–65, 13 figs. Results of experiments carried out on series of side valve turbulent heads of constant head throat area but having head clearances varying in steps of $^1/_{16}$ in. from 0.022 in. to 0.272 in.; in order to investigate possibility of igniting very thin layer of combustible mixture and to obtain information with regard to detonation in small head clearances in Ricardo turbulent head.

Diesel. New Sauer Automobile Diesel (Der neue Saurer Fahrzeug-Dieselmotor), Bruederlin. schweizerische Bauzeitung (Zurich), vol. 95, nos. 12 and 13, Mar. 22, 1930, pp. 151–156, and Mar. 29, pp. 170–174, 26 figs. Description of 4- and 5-cylinder Diesels; bore and stroke 110x180 mm. and 110x150 mm., 40 hp. at 1200 r.p.m. and 80 hp. at 1600 r.p.m.; development and fundamental theory of oil engine reviewed; numerous diagrams and data on injection, combustion process, economy and performance.

Ignition. Coil Ignition, F. W. Lanchester. Instn. Automobile Engrs.—Proc. (Lond.), vol. 23, 1928–29, pp. 214–44 and (discussion) 245–253, 19 figs. Origin of ignition coil; theory of Ruhmikorf coil; number of turns necessary in secondary windings; design of primary condenser; discussion of question of coupling; improved method of operating induction coil; various systems of automatic advance.

AUTOMOBILES

Front-Wheel Drive. Front-Wheel Drives, P. M. Heldt. Soc. Automotive Engrs.—Jl., vol. 26, no. 3, Mar. 1930, pp. 352–360 and (discussion) 360, 8 figs. Engineering consideration leading to former almost universal practice of steering with rear wheels are reviewed, and desire for bodies lower than can be made reason for present interest in front drives.

Riding Qualities. Riding Qualities of Automobiles Determined by Rate of Vibration, J. W. Watson. Automotive Industries, vol. 62, no. 12, Mar. 22, 1930, pp. 470–472. Attainment of higher degree of comfort in cars is possible with reversal of present practice in designing suspension systems; what makes car comfortable or otherwise is not that springs are weak or stiff, nor that weight supported by them is light or heavy, but rate at which rider's movement is accelerated or retarded.

B

BEARING METALS

Phosphor-Bronze. Modern Bearing Metals With Special Regard to Phosphor Bronze (Neure Lagermetalle, unter besonderer Berueckschtigung von Phosphorbronze), D. Schulz. Automobiltechnische Zeit. (Berlin), vol. 33, no. 9, Mar. 31, 1930, pp. 224–225. Results of tests of Caro bronze bearing metal with 8 to 9 per cent tin content, claimed to be especially well adapted for automobile engines.

BOILERS

Furnaces, Combustion in. Admission of Combustion Air (Die Technik der Zufuehrung von Verbrennungsluft), R. Fehling. Archiv. fuer Waermewirtschaft (Berlin), vol. 11, no. 4, Apr. 1930, pp. 119–123, 5 figs. Thermal and aerodynamic conditions of combustion-air admission are discussed; nature of turbulence, its influence on combustion, and relation between air admission and heat transfer in furnace.

Furnaces, Radiation in. Measurement of Flame Radiation in Boiler Furnaces (Messungen der Flammenstrahlung in Dampfkesselfeurungen), P. Koessler. Zeit. des Bayerischen Revisions-Vereins (Munich), vol. 34, nos. 6 and 7, Mar. 31, 1930, pp. 75–78, and Apr. 15, pp. 95–98, 4 figs. Mar. 31: Fundamentals for calculation of radiation of gases and soot suspensions are briefly set forth, and it is shown that radiation of soot suspensions in flame greatly exceeds that of gases; description of testing equipment. Apr. 15: Tests of traveling-grate stokers.

High-Pressure. Benson plus Loeffler, W. Firing, Power, vol. 71, no. 15, Apr. 15, 1930, pp. 587–588, 1 fig. Practical discussion of combining two systems into one unit; sketch of possible combination is diagrammatically outlined.

Boilers for Very High Pressure (Les chaudiéres à tres haute pression), G. Bricard. Revue Industrielle (Paris), vol. 60, no. 2246, Jan. 1930, pp. 33–38, 8 figs. General discussions of types; characteristics of Hanomag and Humboldt boiler compared; notes on Atmos boiler; sectional drawings taken from various journals are given.

Foreign Developments in the Use of High Pressure Steam, J. B. Crane. Combustion, vol. 1, no. 10, Apr. 1930, pp. 39–41, 8 figs. Review of development of high-pressure boilers, which has been somewhat different in Europe than in United States. Supplement of paper "Progress in the Use of High Pressure Steam" by authors, presented before Am. Soc. Mech. Engrs., Mar. 25.

Large Modern Boilers (Les grandes chaudiéres moderne) H. Brés. Revue Industrielle (Paris), vol. 60, no. 2246, Jan. 1930, pp. 19–32, 13 figs. General outline of modern boiler practice, notes on use of high steam pressures and high superheating temperatures and their generation; Benson, Loeffler, and Schmidt boilers and their accessories, pulverized-coal firing; cross-section drawings of some high-pressure boilers are given.

Pulverized Coal-Fired. General Operation Experiences With the First Wood Steam Generator, E. W. Smyth. Mech. World (Manchester), vol. 87, no. 2252, Feb. 28, 1930, pp. 193–195 and (discussion) no. 2254, Mar. 14, 1930, pp. 242–244, 5 figs. Table of results of tests conducted during 1927; slag troubles; tube failures; arrangement of superheater, economizers and soot blowers. Abstract of paper presented before Instn. Mech. Engrs.

Tubes, Stresses in. The Thickness of Boiler Tubes, J. G. Docherty. Engineering (Lond.), vol. 129, no. 3354, Apr. 25, 1930, pp. 527–529, 9 figs. Author presents simple method of deducing "equivalent" or "resultant" stress in tubes of any given thickness under given conditions of heat flow and pressure, and gives minimum equivalent stress under these conditions.

Water-Level Indicators. New Water-Level Indicator (Ein Neuer Wasserstandsanzeiger), W. Jaekel. Die Waerme (Berlin), vol. 53, no. 13, Mar. 29, 1930, pp. 251–252, 7 figs. Description of gage based on hydrostatic principles, for indicating and recording water level in pressure vessels, (boilers and Ruths steam accumulators).

BRASS

Foundry Practice. Casting Boiler Accessories in the Penberthy Plant, J. Breakey. Can. Foundryman (Toronto), vol. 21, no. 4, Apr. 1930, pp. 13–15, 4 figs. Methods and equipment employed by Penberthy Injector Co., Windsor, Ont., in making brass parts for steam power plants; all castings are molded by means of two Tabor jolt-squeeze machines, patterns all being in form of match plates; core making.

Silicon, Effect on. Effects of Silicon on the Properties of Brass, H. W. Gould and K. W. Ray. Metals and Alloys, vol. 1, no. 10, Apr. 1930, pp. 455–457, 3 figs. Structure of brass containing silicon has been studied for two copper-zinc ratio series; silicon forms homogeneous alpha solutions with 85–15 brass if present to extent of not more than 2.8 per cent; it does not form homogeneous alpha solutions with 60–40 brass; silicon lowers freezing point of 85–15 and 60–40 brasses when present in amounts up to 10 and 7 per cent respectively; many of silicon brasses are subject to heat treatment.

BUILDINGS

High, Engineering Problems of. Engineering Problems of the Modern Skyscraper, D. P. Albert. Universal Engr., vol. 51, no. 2, Feb. 1930, pp. 17–20, 6 figs. Brief history of skyscraper development; description of design features of Chrysler Building; water pumping and elevator equipment.

C

CARS

Aluminum. Aluminum Gaining in Favor for Car Construction, C. A. Faust. Elec. Ry. Jl., vol. 74, no. 4, Apr. 1930, pp. 184–190, 11 figs. Experience with many vehicles built largely of aluminum alloys has proved economic value of this metal, from standpoint of both operation and maintenance; table listing equipment in which aluminum has been used with weight data and other pertinent information.

Passenger, Draft Gears for. Draft Gears for Passenger Cars, C. T. Ripley. Ry. Mech. Engr., vol. 104, no. 3, Mar. 1930, pp. 125–126 and 130, 1 fig. Jerking or surging of train, caused by locomotive and transmitted by draft gears not properly designed for service is considered; draft gears should dissipate locomotive surging; tests made with dynamometer car. Abstract of paper presented before Pueblo Car Men's Assn.

Refrigerator, Silica Gel. Silica-Gel Refrigerator System. Ice and Refrigeration, vol. 78, no. 4, Apr. 1930, pp. 331–334, 5 figs. Composition and properties of silica gel; temperature controlled by two thermostats; diagram showing temperature curves on shipment of pears from Yakima Valley, Washington to New York City; illustrated description of silica gel refrigerator car and method of car temperature regulation.

CAST IRON

Properties. Gray Iron Possesses Valuable Engineering Properties. Foundry, vol. 58, nos. 7 and 8, Apr. 1, and May 1, 1930, pp. 111–115 and 209–212, 21 figs. Apr. 1: Effect of silicon and carbon in gray iron; tests and casting of test bars; curves showing relation of cooling time to ratio of volume to surface area; tensile strengths of various types of cast iron determined on standard test bars; tensile and transverse strength tests of cast iron in relation to ratio of volume to surface area; stress-strain diagrams for different types of cast iron; tables with data on classification of cast irons on Si plus C content; volume to surface-area relationships; routine tensile tests; various high-strength irons poured in regular practice. May 1: Effects of repeated stressing on cast iron are described; physical properties given and changes in structure discussed; reference made to J. T. MacKenzie's article in proceedings A.S.T.M. 1929.

Testing. The Effect of Melting Conditions on the Microstructure and Mechanical Strengths of Grey Cast Irons Containing Various Amounts of Carbon and Silicon, A. L. Norbury and E. Morgan. Iron and Steel Inst.—Advance Paper (Lond.), May 1930, 20 pp., 21 figs. Part 1 contains results of experiments on effects of melting conditions, such as superheating, additions of steel, silicides, graphite, gases, and iron oxide; part 2 gives results of tensile, transverse, repeated impact, Brinell drill-hardness, and specific gravity tests on cast irons having total carbon contents between 1.5 and 4.0 per cent, and silicon contents between 0.5 and 10 per cent.

CHROMIUM-NICKEL ALLOYS.

Properties. Nickel-Chromium Alloys, J. H. Russell. Metal Industry (Lond.), vol. 36, nos. 14 and 16, Apr. 4, 1930, pp. 377–379, and Apr. 18, pp. 429–431, and (discussion) 431–432. Outstanding features in these alloys as nickel content increases is that they become more resistant to heat; alloys become less liable to oxidation, and maintain good mechanical properties at quite high temperatures; brittle range; heat-resisting nickel-chromium alloys; wire drawing of nickel-chromium rods; production of nickel-chromium tape; castings; industrial-furnace parts. Paper read before Coordinated Societies, Mar. 10.

Some Alloys for Use at High Temperatures.

W. Rosenhain and C. H. M. Jenkins. Iron and Steel Inst.—Advance Paper (Lond.), May 1930, 80 pp., 24 figs. Investigations carried out at National Physical Laboratory relates to preparation and mechanical properties of alloys of nickel containing 20 to 40 per cent chromium but certain sections include alloys containing 0 to 60 per cent chromium; development of complex alloys of especially high strength must be regarded as still in preliminary stage although considerable advance has been made.

CHROMIUM STEEL

Chromium - Copper. Chromium-Copper Structural Steels, J. A. Jones. Iron and Steel Instn. Advance Paper (Lond.), May 1930, 9 pp. Investigation of steels containing 0.3 per cent carbon, 0.5 to 1 per cent manganese, up to 1.5 per cent chromium and up to 1.2 per cent copper; steels containing chromium in addition to manganese do not offer advantage for structural purposes over usual type of steel containing high manganese only; addition of 0.5 to 1.2 per cent of steel containing high manganese only; addition of 0.5 to 1.2 per cent of copper to steels containing up to 1 per cent of copper to steels containing up to 1 per cent of chromium leads to marked improvement in properties.

Properties. The Properties of Some Steels Containing Chromium, A. R. Page and J. H. Partridge. Iron and Steel Inst.—Advance Paper (Lond.), May 1930, 23 pp., 11 figs. Experiments were originally designed to determine properties of steels suitable for exhaust valves of air-cooled internal-combustion engines; two important properties are: good mechanical strength combined with toughness at ordinary and elevated temperatures, and resistance to oxidation or scaling at temperatures to which exhaust valve may be heated under bad engine conditions; this temperature may reach 800 to 900 deg. cent.

CLUTCHES

Magnetic. How to Select Magnetic Clutches, W. H. Costello. Power, vol. 71, no. 14, Apr. 8, 1930, pp. 548–551, 7 figs. Magnetic clutches are generally considered power transmission equipment, but they may be used to good advantage for power-factor correction with synchronous motors, adjusting machine or motor capacity to suit demand, as unloader on air compressors and on accumulator pumps and as safety devices; friction lining area.

COMBUSTION

Surface. Surface Combustion, M. V. Hurst. Foundry Trade Jl. (Lond.), vol. 42, no. 711, Apr. 3, 1930, p. 252, 1 fig. Description of Cox system of surface combustion, the invention of Bone; system utilizes gas from coal, etc., which, mixed with correct proportion of air at pressure of 3 in. of water, is fed to "combustors" formed of granulated material compressed into various shapes, on surface of which mixture burns without visible flame. Abstract of paper read before Junior Instn. of Engrs.

CONSISTOMETERS

New Type. A New Consistometer and Its Application to Greases and to Oils at Low Temperatures, R. Bulkley and F. G. Bitner. Rheology—Jl., vol. 1, no. 3, Apr. 1930, pp. 269–282, 8 figs. Construction and method of operation of consistometer alleged to be rugged, simple, speedy, and can be employed for opaque and clear materials of wide range of consistencies; material may be passed through capillary any number of times; determinations of rate of flow are made by passing very small volume through capillary; unworked, as well as worked, consistency may be closely approximated; calibration of capillaries; sources of error; flow-pressure graphs of plastic lubricants.

CONVEYORS

Control. Speed Regulation and Control of Conveyors, A. F. Redman. Cassier's Mech. Handling (Lond.), vol. 17, no. 1, Jan. 1930, pp. 10–16, 16 figs. Improvement in design of conveyor equipment during last few years has made rapid progress, and inclusion of specialized reduction and control gear has become matter of importance; speed variation by electrical means; mechanical reduction gears; "Veratio" gear Humfrey Sandberg uni-directional clutch; ring of rollers; J.F.S. reduction gear; O.I.V. chain gear; Crofts gear; variable speed transmission by oil-gear.

Gravity Roller. A New Type of Gravity Roller Conveyor. Cassier's Mech. Handling (Lond.), vol. 17, no. 3, Mar. 1930, p. 82, 1 fig. Description of new type conveyor manufactured by Universal System of Machine Moulding and Machinery Co., Ltd., which is fitted with special steel rollers; conveyor specifications are given.

COOLING TOWERS

Calculation of. Cooling Towers and Spray Ponds and Their Calculation, L. Hansen. Southern Power Jl., vol. 48, no. 2, Feb. 1930, pp. 105–106. Discussion of good judgment in selection of cooling tower or spray pond; atmospheric or natural draft and forced-draft cooling towers; determination of amount of air necessary to cool given quantity of air per minute.

Concrete. Reinforced-Concrete Cooling Towers, A. T. J. Gueritte. Structural Engr. (Lond.), vol. 8, no. 3, Mar. 1930, pp. 177–125, and (discussion) no. 4, Apr. 1930, pp. 141–143, 15 figs. Evolution of cooling-tower construction; several modern examples of concrete cooling tower construction in Europe.

COPPER ALLOYS

P. M. G. P. M. G. Metal for Replacing the Bronzes, M. A. Hunter. Heat Treating and Forging, vol. 16, no. 3, Mar. 1930, pp. 344–345. Hardened copper alloy can be utilized in all situations where high tensile strength is required; alloy as cast contains as it major constituents 2 per cent of iron and 3.4 per cent of silicon with 2 per cent of zinc; hardening is presumably due to presence of iron silicide; this compound dissolves at high temperatures in molten copper; on cooling, iron silicide precipitates from solid solution in such manner as to increase hardness of solidified alloy; metal can be readily forged hot.

CRANES

Cableway. Installation of Cableway Cranes (Installation de grue a cables). Génie Civil (Paris), vol. 96, no. 13, Mar. 29, 1930, pp. 301–304, 10 figs. Description of cableway crane installation at Beuthe, to serve triangular area, for Graeflich Schaffgotsche Werke coal mines; span is 290 m. long, steel frame towers are 36.6 m. high and lifting capacity is 14 tons.

Electric, Aluminum-Alloy. 10-Ton Crane Built of Aluminum Alloy, F. V. Hartman and E. C. Hartmann. Elec. World, vol. 95, no. 11, Mar. 15, 1930, p. 552, 3 figs. New application of strong alloys of aluminum in field of structural engineering is found in 10-ton traveling crane installed in works of United States Aluminum Co., Massena, N. Y.; crane is three-motor, single-hook machine with lift of 22 ft.; girder are constructed of aluminum alloys and have span of 72 ft. 2 in.; built by Alliance Machine Co., Alliance, Ohio.

Gantry. Helpmates for Heavy Duty Cranes, H. T. Hansen. Matls. Handling and Distribution, vol. 3, no. 6, Mar. 1930, pp. 78, 80, and 82, 7 figs. Description of various types of light gantry cranes and illustrated discussion of specific applications.

CUPOLAS

Design. Main Dimensions of Foundry Shaft Furnaces (Cupolas) (Die Hauptabmessungen von Giessereischachtoefen), B. Osann. Giesserei (Duesseldorf), vol. 17, no. 13, Mar. 28, 1930, pp. 293–297. Different methods of calculating main dimensions are developed and critically evaluated.

CUTTING TOOLS

Tungsten Carbide. Alloys With Hardness of Diamonds (Diamantharte Legierungen), S. Malowan. Giesserei-Zeitung (Berlin), vol. 27, no. 8, Apr. 15, 1930, pp. 219–220, 4 figs. Brief note on some alloys used as cutting tools, including tungsten-carbide; Lohmann volomit, consisting of tungsten-cobalt, nickel, and chromium carbides; thoran, which is carbide of thorium and tungsten; and new Widia alloys of Krupp; advantages of hard alloys are set forth.

Tungsten Carbide Cutting Tools Are Winning Greater Favor, O. K. Parmiter. Iron Trade Rev., vol. 86, no. 15, Apr. 10, 1930, pp. 71–74, 3 figs. Consideration of correct angles, rakes and clearances, and grinding procedure.

D

DIE CASTING

Brass Alloys for. Brass Pressure Die Castings (Der Messing-Pressguss), W. Mueller. Giesserei Zeitung (Berlin), vol. 27, no. 6, Mar. 15, 1930, pp. 155–156, 9 figs. Brass as successor to tin-zinc-aluminum die casting is said to be latest discovery in field of die castings; its advantages are set forth and casting method is described.

DIES

Stamping. Metal Stamping Dies—Die Layout and Construction, E. E. Clark. Metal Stampings, vol. 3, no. 4, Apr. 1930, pp. 323–328, 10 figs. Discussion of factors affecting choice between built-up and solid types of die construction; including type of tool, materials available and their characteristics, costs, repairs, etc.

Steel for. New Tool and Die Steels Give High Production, O. K. Parmiter. Iron Trade Rev., vol. 86, no. 16, Apr. 17, 1930, pp. 52–54, 4 figs. Desirable properties of chromium-molybdenum-vanadium steel; fields of application; comparative value of die steels; evolution of high-speed steel.

DIESEL-ELECTRIC POWER PLANTS

British Columbia. The Selection of a Mine or Mill Power Plant, G. R. Frizell. Can. Min. Jl. (Gardenvale, Que.), vol. 51, no. 14, Apr. 4, 1930, pp. 317–319, 1 fig. Notes on power plant of Base Metals Mining Corp. at Field, B. C.; two 400-hp. six-cylinder, Fairbanks-Morse Diesel engines, each direct connected to 375-kva. alternator; one 180-hp., three-cylinder, Fairbanks-Morse Diesel engine direct connected to 150-kva. alternator, with alternator shaft of last mentioned engine extended through outboard bearing and connected through friction clutch to 18-in. × 11-in. × 14-in. right-angle compound air compressor; current gathered is three-phase, 60-cycle, 480 volts.

LaCrosse, Kan. Nine-Year Operating Record of Diesel Plant. Power Plant Eng., vol. 34, no. 9, May 1, 1930, pp. 502–504, 2 figs. Care in keeping complete records and in analyzing operating costs aids materially in reducing costs of maintenance and operation at Diesel-engine plant of La Crosse, Kansas; summary of nine years operating record; table showing operating costs for nine-year period.

DIESEL ENGINES

Airless Injection. Recent Developments in the Airless Injection of Fuel in Diesel Engines. Fuel (Lond.), vol. 9, no. 3, Mar. 1930, pp. 130–140, 18 figs. In recent years airless injection has been more and more adopted, since it gives higher thermal efficiency than blast injection by eliminating injection air compressor and power required to drive it; it also cheapens engine and simplifies attendance; engines with precombustion chambers and with supplementary compression; phenomena in fuel piping; there is tendency to do away with camshaft altogether in two-cycle engines, especially in double-acting engines.

Balancing. Balancing of Oil Engines (Ueber den Massenausgleich von Oelmotoren), F. Schmidt. Werft Reederei Hafen (Berlin), vol. 11, no. 3, Feb. 7, 1930, pp. 49–54, 27 figs.; see also translated abstract in Mar. Engr. and Motorship Bldr., vol. 53, no. 631, Apr. 1930, p. 157. To facilitate task of engine designer in ensuring absence of vibration, author investigates by method of harmonic analysis, balancing reciprocating and rotating masses of Diesel engines having from 3 to 9 cylinders; rigidity of whole engine is of greatest importance to successful balancing; as example, case of 6-cylinder engine, consisting of two blocks of three balanced against each other, is given.

Combustion in. Combustion in Diesel Engines, H. R. Ricardo. Automobile Engr., vol. 20, no. 266, Apr. 1930, pp. 151–156, 18 figs. Discussion of combustion problem in high-speed Diesel engines, operating at piston speeds in excess of 1500 ft. per min.; factors upon which building up of self-propagating nucleus of flame and spread of flame throughout working fluid depend.

M.A.N. Marine. Large Two-Stroke Double-Acting Oil Engines for Land and Marine Work. Engineer (Lond.), vol. 149, no. 3875, Apr. 18, 1930, pp. 430–431, 4 figs. Installation at Hennigsdorf peak-load substation comprises two 10-cylinder M.A.N. two-stroke double-acting engines operating on airless-injection principle; each has designed output of 11,700 b.hp. at 214 r.p.m.; details are also given of 6-cylinder two-stroke, double-acting, airless-injection engine which is first of this type, and forms one of two sets to be installed in 15-knot, 10,000-ton cargo liner under construction at yard of Yokohama Dock Co. for service of Kishimoto Kisen Kaisha.

Solid-Injection Double-Acting Two-Stroke Diesel Engines, A. Heller. Eng. Progress (Berlin), vol. 11, no. 4, Apr. 1930, pp. 110–112, 2 figs. Engine is one of six which Yokohama Dockyard Co. is installing in three of their ships; bore 23.7 in.; stroke 35.5 in.; speed 130 r.p.m.; b.hp. 3600–3750 hp.; M.A.N. scavenging process employs slots in cylinder wall both for exhaust and for admission of scavenge air, so that no valves are necessary; adoption of solid fuel injection for so large outputs represents important stage in development of double acting two-stroke Diesels, possibilities of which M.A.N. were first to put into practice.

E

ECONOMIZERS

Design. Modern Preheater Design (Der neuzeitliche Vorwaermerbau), H. Baleke.

Brennstoff und Waermewirtschaft (Halle), vol. 12, no. 3 and 4, Feb. 1 and 2, 1930, pp. 29–43, 23 figs. General description of various German makes of economizer and air preheaters; curves of steam and heat consumption, and photomicrographs of raw water of different compositions, are given. Paper before Russian Trade Soc., Berlin.

Draft Requirements. Size and Draft Requirements of Economizer and Air-Heater Installations (Groesse und Zugbedarf von Ekonomiser- und Lufterhitzeranlagen- die wirtschaftliche Bedeutung der richtigen Bemessung), Kratsch. Waerme (Berlin), vol. 53, no. 13, Mar. 29, 1930, pp. 241–245, 10 figs. Economic importance of correct dimensions is set forth; study of relations between area of heating surface, efficiency, and draft resistance, with use of artificial draft in economizers and air-heater installations.

ELECTRIC FURNACES

Annealing. The Gruenewald Method of Bright Annealing, R. W. Miller. Iron and Steel Industry (Lond.), vol. 3, no. 6, Mar. 1930, pp. 181–183, 8 figs. Method depends on providing charge against oxidation while charge is cooling down, but instead of using inert gas to prevent air from reaching material, as in Vitry method, annealing pot is rendered airtight when maximum temperature is reached, principle being similar to that used for preserving fruit and other foodstuffs.

Heat-Treating. Heat Treatment Furnaces, A. G. Lobley. Automobile Engr. (Lond.), vol. 20, no 265, Mar. 1930, pp. 110–111, 4 figs. Two primary advantages of electric furnace are exactitude of control and flexibility; comparison between working costs of electric and gas-fired furnaces; calculated differences of temperature between resisters and furnace.

The Tangible Advantages of Electric Heat Treatment, W. S. Scott. Iron and Steel Engr., vol. 7, no. 3, Mar. 1930, pp. 118–122, 3 figs. Savings resulting from use of electric heat-treating furnaces are classified according to quality of product; these savings briefly discussed.

ELECTRIC WELDING

Arc. Transfer of Electrode Metal in the Welding Arc, A. Hilpert. Welding Engr., vol. 15, no. 4, Apr. 1930, p. 44, 1 fig. Welding arc was photographed in 1927 upon suggestion by author; Society of German Engineers conducted systematic investigation of transfer of metal; shadowgraphs are shown of transfer of molten metal from electrode tip to weld seam; shape changes considerably within 1/1600th second, hence it is necessary to operate with very large number of pictures when investigating transfer of working metal in arc welding. Abstract translated from V.D.I. Zeit., 1929.

Welding Iron and Steel by Electric Arc, O. A. Tilton. Welding, vol. 1, nos. 4 and 5, Feb. 1930, pp. 229–231, and Mar., pp. 314–317, 9 figs. Feb.: Fundamental principles and various applications are discussed; data pertaining to electrodes and fillets; potential of welding current; capacity of welding equipment. Mar.: Important factors for obtaining good welds; fabrication costs; training welding operators.

Resistance. Design of Resistance Welding Machines, W. E. Smith. Welding Engr., vol. 15, no. 2, Feb. 1930, pp. 55–56, 2 figs. Strength of parts, method of applying pressure, elimination of magnetic losses, and insulation, are some of factors to be considered.

Riveting and Upsetting Operations by Resistance Welding, A. E. Hackett. Welding, vol. 1, no. 5, Mar. 1930, pp. 301–304, 9 figs. Examples of application of resistance welding process to alloy-steel studs, propeller shaft, and ventilating fan; use of electric welding machine for cutting steel cables.

EMPLOYMENT MANAGEMENT

Europe. Progress Achieved by Application of Scientific Management of Labor (Les Progrés Realisés dans l'Application de l'Organisation Scientifique du travail), C. De Fréminvillé. Société d'Encouragement pour l'Industrie Nationale—Bul. (Paris), vol. 129, no. 1, Jan. 1930, pp. 31–66. Congress of Paris of 1929 has important period in development of scientific management methods in agriculture, commerce, and industry, in public and private enterprise; work of sections of congress are discussed; appendix 1 discusses influence of scientific organization, appendix 2 gives report of commission of recent charges; appendix 3 discusses report presented at 4th International Congress.

EXTENSOMETERS

Huggenberger. The Huggenberger Tensometer. Engineering (Lond.), vol. 129, no. 3353, Apr. 18, 1930, pp. 502–503, 4 figs. Very simple yet sensitive and accurate strainmeter, designed and made by Huggenberger of Zurich, magnifies actual strains by 1200 so that accurate measurements may be made on gage length of as little as 1/2 in.

F

FEEDWATER TREATMENT

Degasification. An Improved De-Aerator for Boiler Feedwater. Engineer (Lond.), vol. 149, no. 3871, Mar. 21, 1930, p. 332, 3 figs. New type of de-aerator with self-contained heater has been built by Mirrless-Watson Co., Glasgow, in order to render feedwater innocuous to boilers and to economizers.

High-Pressure System. Development of a High-Pressure System for Boiler Water Conditioning, A. A. Markson. Combustion, vol. 1, no. 10, Apr. 1930, pp. 27–30 and 34, 3 figs. Description of high-pressure system, using Hall phosphate treatment, as developed at Kip's Bay Station of New York Steam Corporation and later installed at Station A, operated by same company; theoretical aspects of work are fully discussed, and equipment and operation described in some detail; definite conclusions offered based on nearly 12 months experience. Abstract of paper presented before Am. Soc. Mech. Engrs.

Phosphate Treatment. Phosphate Treatment of Boiler Water, E. P. Price. Combustion, vol. 1, no. 7, Jan. 1930, pp. 35–38, 5 figs. Brief review of principal difficulties incident to rapid changes in operating practice and results of experiments conducted on strictly commercial bases extending over period of two and one-half years; description of feedwater testing apparatus.

Softening. Experience With Zeolite and Acid at Beacon St. Plant, J. H. Walker and L. F. Collins. Power, vol. 71, no. 14, Apr. 8, 1930, pp. 552–555, 3 figs. Discussion of operation of zeolite feedwater treating system installed in plant of Detroit Edison Co., which has been in operation for 3 1/2 years; diagram of feedwater system; table of water analyses at various points in cycle; table giving annual operating cost of feedwater treating system.

FOUNDRY EQUIPMENT

Driers. Drying of Molds and Cores at Low Temperature and Slight Gas Fluctuation (Ueber Trocknen von Formen und Kernen bei niedriger Temperatur und geringem Gasechsel), W. Mann. Giesserei (Duesseldorf), vol. 17, no. 15, Apr. 11, 1930, pp. 349–352, 8 figs. At temperatures exceeding 100 deg. cent. there is no relative moisture in steam-air mixtures; heat utilization is influenced by state of gases admitted and discharged; reducing temperature changes by increased circulation; description of new driers, based on these principles and their heat-balance rules for economic water evaporation and drying.

FUELS

Calorific Value. Determination of Calorific Values of Liquid and Gaseous Fuels (Etwas ueber Heizwertbestimmungen fluessiger und gasfoermiger Brennstoff). Waerme and Kaelte Technik (Muehlhausen), vol. 32, no. 5, Mar. 18, 1930, pp. 4–6. Brief discussion of methods and their reliability, and precautions to be observed in measuring calorific values of liquid and gaseous fuels.

FURNACES

Melting, Oil-Fired. Schury Furnace (Der Schury-Ofen), F. Brocke. Giesserei-Zeitung (Berlin), vol. 27, no. 7, Apr. 1, 1930, pp. 195–197, 4 figs. Description of German patented steel-melting furnace especially well adapted for foundries with fluctuating load; advantages include short heating and melting period which, together, require only 5 1/2 to 6 hr.; it is a hearth furnace, with regenerator, and can be fired with tar, tar oil, or other oils; comparison of heat balance of this intermittent furnace with that of continuous gas-fired open-hearth furnace.

Melting, Pulverized-Coal. Melting Iron in the Rotary Furnace (La fusion de la fonte au four rotatif), C. Bouvard. Fonderie Moderne (Paris), vol. 23, Dec. 10, 1929, pp. 575–580, 3 figs. Processes of melting iron; advantages of pulverized-coal-fired rotary furnace lie in attaining very high temperatures without oxidation of metal; securing quality of finished iron differing very little from constituents of charge; possible diminution of carbon contents due to elevated temperatures; furnace heated by pulverized coal; economy of process.

G

GEARS

Grinding. Some Developments in the Art of Gear Grinding. Engineer (Lond.), vol. 149, no. 3874, Apr. 11, 1930, pp. 397–400, 7 figs. Methods and equipment employed at works of Gear Grinding Co., Birmingham, which receives from makers of different equipment cut and hardened spur wheels, and returns them with flanks and roots of teeth finished by grinding to high degree of accuracy; it also undertakes grinding of multiple-spline shafts; grinding process employed consists of traversing through gaps of work abrasive wheel, shape of which is maintained by means of three diamonds in form requisite to give correct shape and thickness to teeth.

Reduction. Reduction Gears, J. A. MacMurchy. Elec. Jl., vol. 27, no. 4, Apr. 1930, pp. 213 and 227. High-grade gear of present day is as reliable as any other machine built; with proper lubrication of bearings and gear teeth, modern reduction gear system will outlast either driving or driven apparatus.

GLIDING

Dynamic. Observations of Dynamic Gliding (Beobachtungen ueber dynamischen Segelflug), L. Prandtl. Zeit. fuer Flugtechnik und Motorluftschiffahrt (Munich), vol. 21, no. 5, Mar. 14, 1930, p. 116, 2 figs. Description is given of how seabirds (brown albatrosses) actually soar on ocean surface, based on author's observations on voyage from Yokohama to Honolulu.

H

HEAT-INSULATING MATERIALS

Masonite. The Masonite Process, R. M. Boehm. Indus. and Eng. Chem., vol. 22, no. 5, May 1930, pp. 493–497, 5 figs. History of process used by Masonite Corp., Laurel, Mass., for manufacture of insulating board by exploding wood chips under 1000 lb. per sq. in. steam pressure; description of products including Insulation Board, Insulation Lath, Quarterboard, and Presdwood.

HEAT TRANSMISSION

Research. Studies in Heat Transmission, A. P. Colburn and O. A. Hougen. Indus. and Eng. Chem., vol. 22, no. 5, May 1930, pp. 522–539, 20 figs. Measurement of fluid and surface temperatures; flow of heat through tubular gas condenser, heat-transmission coefficients were measured separately for water film, metal, condensate layer, and adjoining gas film; flow of fluids at low velocities.

HYDRAULIC TURBINES

Design. Features of New Low-Head Hydraulic Turbine Design, H. J. Muth. Power, vol. 71, no. 17, Apr. 29, 1930, pp. 664–667, 9 figs. New development in low-head hydraulic turbine design and power house construction that provides flexibility between turbine unit and power house structure and reduces cost of construction is described.

Kaplan. Hydro Efficiency Increased 10 Per Cent, C. L. Dowell. Elec. World, vol. 95, no. 14, Apr. 5, 1930, pp. 684–686, 6 figs. Subjected to severe tests of its ability to perform efficiently and continuously, first Kaplan automatic adjustable blade waterwheel installed in America has successfully completed more than nine month service at Lake Walk Plant of Central Power and Light Co.; flow of Devil's River was extremely low; performance curve based on 33-ft. net head and 277 r.p.m. are given; efficiency and horsepower curves are compared.

Vibrations. On the Vibration of Draft Tube of Water Turbine, S. Uchimaru and S. Kito. Tokyo Imperial Univ. Faculty of Eng.—Jl. (Tokyo), vol. 18, no. 8, Feb. 1930, pp. 213–270, 39 figs. Theoretical mathematical analysis of causes and methods of preventing of vibrations of draft tubes, of hydraulic turbines running on part load, based on theory of vibration of columnar vortex confined in cylindrical space; also report on experiments on vibrations of cylindrical draft tubes; effect of placing disk at bottom of tube; effect of introduction of air into draft tube. (In English.)

I

ICE PLANTS

Design. Advantages of Two Suction Pressures for Ice Plant, G. T. Voorhees. Ice and Refrig., vol. 78, nos. 1, 2, 3, and 4, Jan., Feb., Mar., and April, 1930, pp. 66–67, 156–157, 264–266, and 353–356, 6 figs. Jan.: Forecooler's part in power economy; old method's seasonable

reduction thereof eliminated by new process; analysis of high suction effort and how to utilize it with all types of compression apparatus; indicator diagram showing condenser pressures in hot and cold months. Feb.: Forecooler's part in power economy; old method's seasonable reduction thereof eliminated by new process; analysis of high suction effort and how to utilize it with all types of compression apparatus; comparative indicated compressor horsepower diagram, reproduced at exact size, is given. Mar.: Diagram of suction pressure in pounds per square inch gage for solving power problems. April: Diagrammatic illustration of can forecooler cycle; indicator diagrams for various clearances; displacement and power chart, no clearance, for ammonia compressors, also tons of refrigeration per ton of ice.

INDUSTRIAL MANAGEMENT

Control. Control and Size in Management, H. Coonley. Taylor Soc.—Bul., vol. 15, no. 1, Feb. 1930, pp. 18–22. Consideration of tangible, knowable, and largely controllable forces in management such as control of materials, assignment of labor, budget control and intangible, unknown and uncontrollable factors such as salts, finances, marketing, competition, trade practice, psychology.

Cost Accounting. Smoothing the Road to Predetermined Costs, R. M. Barnes. Factory and Indus. Mgmt., vol. 79, no. 5, May 1930, pp. 1069–1070, 3 figs. Use of hyperbolic charts in showing relationship between fixed and variable costs.

Distribution Problems. Is It Good Management Policy to Assume That Consumer Wants for Particular Goods Are Insatiable? P. H. Nystrom. Taylor Soc.—Bul., vol. 15, no. 2, Apr. 1930, pp. 80–85. Answer is most emphatically "no;" suggestion that consumer wants for particular goods are insatiable is contrary to ordinary common sense and every-day observation; consumers wants for all classes of goods are definitely modified and limited by several factors among which may be mentioned purchasing power, physical limits of consumption, changing living conditions, competition of other goods serving same purposes or even different purposes, and changing consumer tastes.

Do Consolidations Result in Reduction of Distribution Expenses? B. C. Milner, Jr. Taylor Soc.—Bul., vol. 15, no. 2, Apr. 1930, pp. 86–91 and (discussion) 91–98. Generalizations are that consolidations of companies manufacturing competitive products are less likely to effect savings in distribution than are consolidations of manufacturers of non-competitive but allied products salable to same general market; that it is easier to effect savings in cost of distributing standard products generally used than in cost of distributing more specialized products, such as machinery, equipment, or supplies which must be merchandised to comparatively limited clientele.

Optimum Size of Organization. Is There an Optimum Size of Organization, J. H. Williams. Taylor Soc.—Bul., vol. 15, no. 1, Feb. 1930, pp. 22–23 and (discussion) 23–31. Optimum size of each particular organization is dependent upon extent to which personal equation enters into service or product of organization; extent to which authority is decentralized; incentive for cooperation between managers of units exercising authority; extent to which accounting procedure is standardized on basis which will enable effective comparison as between units in terms which will be stimulating to managers of such units.

Production Control. A 3000-Item Line Goes Mass Production, T. R. Hough. Factory and Indus. Mgmt., vol. 79, no. 3, Mar. 1930, pp. 530–532, 2 figs. Flow-production methods in manufacturing sporting goods; product ranges from football uniforms and leather helmets to golf balls and clubs, and involves manufacturing operations with such diversified materials as forged steel, wood, leather, knit, and rubber goods.

Lay-Out Essentials in Mass Production, P. Noble. Cassier's Mech. Handling (Lond.), vol. 17, no. 3, Mar. 1930, pp. 91–92. Manufacture of present-day products invariably involves some form of mass or batch production; layout of operations will be largely deciding factor between efficient method or uneconomic production; preparation of layouts; drawing numbers; foreman's criticism; standard articles.

Production Control Applied in Building Large Machines, R. E. Miller. Iron Age, vol. 125, no. 14, Apr. 3, 1930, pp. 997–1001, 9 figs. Detailed account of planning and control system of Chambersburg Engineering Co., Chambersburg, Pa.; manufacturing standard forging and drop hammers, made in number of types and in wide range of sizes, as well as nine or ten different mechanical and hydraulic presses for various uses; standardization and interchangeability permits manufacture of many parts in stock quantities although no machines are assembled on stock.

Quality Control. Manufacturing to Gauge Accuracy on Production Basis, J. W. Hook. West Machy. World, vol. 1, no. 2, Feb. 1930, pp. 45–47, 5 figs. How changes were made by Geometric Tool Co., to obtain gage accuracy on quantity production basis.

Stores Control. Store Room Control, C. B. Thompson. Taylor Soc.—Bul., vol. 15, no. 2, Apr. 1930, pp. 107–112, 5 figs. New methods in organization of store rooms are discussed under purchasing and maintenance of stock, receiving and inspection, tagging, moving to reserves, moving from reserves to preparation, preparation, verification of preparation, packing, weighing and shipping, and billing and bookkeeping control.

INTERNAL-COMBUSTION ENGINES

Electric Dynamometers for. Electrical Dynamometers for Testing Internal-Combustion Engines. Engineering (Lond.), vol. 129, no. 3351, Apr. 4, 1930, pp. 433–439, 5 figs. Details of dynamometers exhibited by Highfield Electrical Co. at British Industries Fair; two types were shown, one known as production type and other as research type; latter is of enclosed protected type armature being specially constructed to withstand high speeds up to 6000 r.p.m.; in production type power developed by engine is returned in form of electrical energy to mains, thus greatly reducing operating costs.

[See also AIRPLANE ENGINES; AUTOMOBILE ENGINES; DIESEL ENGINES.]

IRON AND STEEL PLANTS

Fuel Economy in. Developments in Fuel Economy at Skinningrove, F. Bainbridge. Iron and Steel Inst.—Advance Paper (Lond.), May 1930, 23 pp., 8 figs. Attempt is made to bring into balance outputs of various producing departments at Skinningrove to make available greater quantities of surplus gas by installation of automatic burners on stoves and boilers, further quantities so liberated being made use of in production of steel; economies have also been achieved by application of coke-oven gas to open-hearth furnace through water-cooled ports or burners.

L

LIGHTING

Industrial. Daylighting Industrial Buildings, A. J. Martin. Am. Architect, vol. 137, no. 2583, May 1930, pp. 36–37, 4 figs. General discussion with curves illustrating principles of daylighting; light cut off by obstructions; increase of daylighting on lower floors; increasing height of windows at lower stories; treating walls of obstruction to reflect more light.

Modern Methods of Factory Lighting. Cassier's Mech. Handling (Lond.), vol. 17, no. 2, Feb. 1930, pp. 51–52, 3 figs. Discussion of good illumination which is essential to operatives' safety; elimination of glare; three lighting systems are discussed.

LIQUID AIR

Containers for. Theory and Design of Metal Vacuum Jacket Containers for Liquified Gases, Especially Liquid Hydrogen (Theorie und Konstruktion der Vakuummantegefaesse aus Metall fuer verfluessigte Gase), etc., W. Meissner. Zeit. fuer die Gesamte Kaelte-Industrie (Berlin), vol. 37, no. 3, Mar. 1930, pp. 41–48, 7 figs. Discussion of heat supply through conductivity of metal and through radiation; heat transfer through conductivity of remaining gas; description of container used in German National Physico Technical Institute; result of test with liquid hydrogen and liquid air to determine relation between evaporation and supplied heat are tabulated.

LOCOMOTIVES

Electric. A 7200 Horse-Power Single-Phase Locomotive. Engineer (Lond.), vol. 149, no. 3872, Mar. 28, 1930, p. 359, 1 fig. For Swiss Federal Railways Oerlikon Company is building what is believed to be largest locomotive so far constructed in Europe; it is described as 1 Bo 1 plus 1 Bo 1 Bo 1 type of engine, symbol 1 meaning one carrying axle, and symbol Bo two driving axles with individual drive.

Electric Locomotive Built by Railroad, R. L. Kimball. Ry. Age, vol. 88, no. 16, Apr. 19, 1930, pp. 911–912, 3 figs. Piedmont and Northern has completed and placed in service 100-ton, 1500-volt, d.c. locomotive; equipment includes eight traction motors, Westinghouse type 562-D5; forced ventilation; battery control; electrically heated cab; K-14-D Westinghouse air brakes; 2 Westinghouse two-stage 75-C compressors; and pedestal-mounted motorman's brake valves; inclined catenary type of construction used; total length over knuckles, 64 ft. 10 in.; total height 15 ft. 9½ in.; total wheelbase 54 ft. 6½ in.; continuous tractive force, 18,550 lb.

Electric Switching and Transfer Locomotives, P. A. McGee. Ry. Age, vol. 88, no. 18, May 3, 1930, pp. 1060–1062, 4 figs. Illinois Central adopts locomotives with characteristics suitable for both classes of service; design includes special weight-transfer compensating features; principal characteristics are: tractive force at normal adhesion of 25 per cent, 50,000 lb.; length over bumpers, 35 ft. 8 in.; total wheelbase, 27 ft. 3 in.; wheel diam. 45 in. total weight 200,000.

Permissible Storage-Battery Locomotives and Power Trucks, L. C. Illsley, E. J. Gleim, and H. B. Brunot. U. S. Bur. of Mines—Bul. 313, 1929, 120 pp., 49 figs. Essential data in regard to construction of approved storage-battery locomotives and power trucks; where number of approvals have been granted to one manufacturer they have been grouped for clearness and brevity; paper has been prepared in three separate sections as follows: Jeffrey-type locomotives and power trucks; Mancha-type locomotives and power trucks; approved locomotives representing product of six manufacturers.

Seven Thousand Two Hundred Hp. Single-Phase Locomotive, Swiss Federal Railways. Ry. Gaz. (Lond.), vol. 52, no. 15, Apr. 11, 1930, p. 551, 1 fig. Largest electric locomotive yet built in Europe; locomotive is classified as 1-Bo-1-Bo-1 plus 1-Bo-1-Bo-1 type; locomotive is to be built as double locomotive with 16 motors in all, two halves being close-coupled; main particulars and dimensions are tabulated.

Fireboxes, Draft Distribution in. Draft Distribution in the Firebox, S. H. Acker. Ry. Mech. Engr., vol. 104, no. 4, Apr. 1930, pp. 184–188 and 207, 12 figs. Results of Frisco draft tests on locomotives equipped with two percentages of air openings in same firebox; conditions under which tests were made; effect of alternating draft-plate height; effect of fire conditions on distribution of draft; effect of air openings and thick fires; theory of 25-35-per cent grates.

High-Pressure. Experimental High-Pressure Locomotive, L.M.S.R. Ry. Engr. (Lond.), vol. 51, no. 601, Feb. 1930, pp. 59–60, 3 figs. New 4–6–0 locomotive incorporates double pressure boiler with three-cylinders operating on compound principle; boiler detail and steam regulation; cylinders 11½ by 18 by 26 in.; driving wheels 6 ft. 9 in.; boiler pressure 900 lb. per sq. in., high pressure and 250 lb. per sq. in., low pressure; tractive force 33,200 lb.; engine wheel base 15 ft. 4 in.; total engine weight in working order, 87 tons.

Super-Pressure Schwartzkopff-Loeffler Locomotive. Engineer (Lond.), vol. 149, no. 3873, Apr. 4, 1930, pp. 371–374, 6 figs. Account of principal features of German Federal Railway locomotive built by Berliner Maschinenbau A. G. (L. Schwartzkopff); it operates at designed working pressure of 120 kg. per sq. cm. or 1700 lb. per sq. in.; weight has been kept same as that of standard express locomotive; Loeffler principle consists in evaporating water to steam in non-fired water and steam drum, by means of highly superheated steam, which is introduced into water in finely divided form.

Ultra High-Pressure Locomotive, German Railways, H. Fuchs. Ry. Engr. (Lond.), vol. 51, no. 603, Apr. 1930, pp. 143–147, 3 figs. Illustrated description of 4–6–2 three-cylinder compound engine constructed on Schwartzkopff-Loeffler system; cylinders 8.66 by 23.62 by 26 in.; driving wheels 6 ft. 6¾ in.; boiler pressure 1700 lb. per sq. in., high pressure and 213 lb. per sq. in. low pressure; total engine weight in working order 113 tons.

Low-Grade Fuel Used in. Screenings Successfully Burned in C. and E. I. Road Test. Ry. Mech. Engr., vol. 104, no. 3, Mar. 1930, pp. 131–135 and 144, 8 figs. Chicago and Eastern Illinois recently conducted some carefully supervised road tests of steam locomotives which demonstrated that with mechanical stoker equipment and Hulson tuyère-type grates, it is entirely feasible to burn 1¼-in. screenings at slightly reduced efficiency as compared with mine-run coal; graphs and tabular data are given.

Passenger. Austrian 2–8–4 Locomotive of Unique Design. Ry. Age, vol. 88, no. 12, Mar. 22, 1930, pp. 685–689, 5 figs. Claimed to be most powerful steam locomotive in Europe; equipped with Lentz poppet valves; important features of design, wheel-arrangement, frame and special equipment; cylinders 25.6 in. by 28.4 in.; driving wheels 76.4 in.; boiler pressure 213 lb. per sq. in.; maximum tractive force 44,100 lb.; total engine weight in working order 260,200 lb.; total engine wheelbase 41 ft. 6 in.

Pacific Type Locomotive Equipped With Poppet Valves. Ry. Age, vol. 88, no. 13, Mar. 29, 1930, pp. 767–768, 2 figs. Delaware and Hudson reports good service with oscillating poppet valves actuated by Walschaerts gear; built with

concealed auxiliaries; operating record; cylinders 22 in. by 28 in. driving wheels 22 in.; boiler pressure 275 lb. per sq. in. rated maximum tractive force 44,000 lb. total engine weight in working order 300,000 lb.; total engine wheel base 35 ft. $3^1/_2$ in.

LUBRICATING OIL

Germ Process. Outline Advantages of Germ Process, B. H. Lincoln. Oil and Gas Jl., vol. 28, no. 42, Mar. 6, 1930, pp. 62 and 236, 1 fig. Small percentages of fatty acid in mineral lubricating oils greatly reduce coefficient of friction; blending fatty acids with mineral oils was called germ process, by analogy, because when suitable acid is dissolved in mineral oils it gives latter life and activity as more perfect instrument of lubrication. Bibliography.

M

MACHINE TOOLS

Fabrication by Welding. Machine Tools Fabricated by Welding, T. H. Booth. Welding, vol. 1, no. 5, Mar. 1930, pp. 321–323, 9 figs. Use of arc-welding machine by Buffalo Forge Co.; brief account of economics effected.

MATERIALS HANDLING

Foundries. Compact Foundry Handling System, S. G. Koon. Iron Age, vol. 125, no. 15, Apr. 10, 1930, pp. 1069–1072, 6 figs. Combination of vertical loop handling sand and horizontal loop handling molds and castings in operation in iron foundry of General Electric Co., Pittsfield, Mass., for last year; it is said to have been productive of gratifying results in lowering cost of making castings and at same time improving their quality; approximately half of molding and of service force, for given production of casting, was eliminated by this system.

Mechanical Handling Operations at Foundry of a Large Motor Works. G. F. Zimmer. Cassier's Mech. Handling (Lond.), vol. 17, nos. 1, and 2, Jan. 1930, pp. 3–4, and Feb., pp. 35–38, 6 figs. Jan.: Description of handling machinery employed at foundry of Morris Motors, Ltd., Conventry; system is most complete of its type in country, no operation being carried out by manual labor that can be performed by mechanical appliances. Feb.: Preparation of molding sand; conveyor details; handling of cores; diagram of flight scraper conveyor negotiating horizontal and vertical paths.

Machine Shops. Handling Materials by Modern Methods. Machy. (N. Y.), vol. 36, no. 7, Mar. 1930, pp. 540–544, 9 figs. Important developments in efficient handling and transporting of materials and work in progress in machine shops; cooperation between builders and users of material-handling equipment; types of trucks; advantages of foot-lift truck; Gantry crane for shop use; examples of efficient equipment; new materials-handling methods in forge shop; methods in large electrical manufacturing plant.

Railroad Repair Shops. Handling and Distributing Materials at Railroad Shops. F. A. Westbrook. Matls. Handling and Distribution, vol. 4, no. 1, Apr. 1930, pp. 26–30, 11 figs. Illustrated description of systems for handling and distributing materials in general repair shops and storehouse of New Haven at Readville, Mass.; issuance of supplies to shop; materials handling in locomotive shop.

METALS

Cold-Working. Textures of Cold-Worked Metals (Texturen kaltverformter Metalle), F. Wever and W. E. Schmid. Zeit. fuer Metallkunde (Berlin), vol. 22, no. 4, Apr. 1930, pp. 133–140, 20 figs. X-ray analysis of aluminum and iron was carried out in order to clear up conflicting theories in earlier studies of texture of rolled material; analysis was made of a homogeneous flow phenomenon, the parallel-piped plane deformation, similar to rolling process; behavior of crystallites in deformation process is discussed on basis of well-known law of slip and bending in single crystal.

Cutting, Charts for. Machine-Shop Data Sheets for Cutting of Steel Castings (Werkstattblaetter fuer die Zerspanung des Stahlgusses), A. Wallichs and K. Krekeler. Automobiltechnische Zeit. (Berlin), vol. 33, no. 8, Mar. 20, 1930, pp. 200–230, 3 figs. Examples of charts are presented which are based on experimental work and contain data on chemical analysis, strength values, experimental conditions, heat treatment, etc., for machining of different grades of steel castings under influence of turning process.

Endurance Testing. Endurance Testing Machine for Alternating Torsional Load (Dauerpruefmaschine fuer Torsionswechselbelastung), W. Spaeth. Werkzeugmaschine (Berlin), vol. 34, no. 3, Feb. 15, 1930, pp. 45–49, 3 figs. Description of equipment of Losenhausenwerk Duesseldorf, employing, swinging motor for drive, which allows for quick and exact execution of various tests.

Wear Testing. Recent Research in Wear of Materials (Neue Ergebnisse auf dem Gebiet der Verschleissforschung), M. Fink. Organ fuer die Fortschritte des Eisenbahnwesens (Berlin), vol. 84, no. 20, Oct. 15, 1929, pp. 405–412, 11 figs. Report on recent cooperative abrasion tests of various steels and copper, with special reference to oxidation process accompanying rapid wear of materials; mechanism of corrugation formation on rails.

MICROSCOPES

Engineering Applications of. The Microscope as Applied to Engineering, J. S. G. Primrose. Manchester Assn. Engrs.—Trans. (Manchester), 1928–1929, pp. 13–20 and (discussion) 20–34, 3 figs. Development in design of microscopes and their application in engineering workshops for purposes of making fine measurements and in metallurgical research for determining microstructure of steel.

MOLDS, FOUNDRY

Asbestos. Production of Asbestos Permanent Molds (Die Herstellung von Asbestdauerformen), G. Wolf. Giesserei Zeitung (Berlin), vol. 7, no. 6, Mar. 15, 1930, p. 154. Requirements of non-metallic molds are briefly set forth; best molding materials is claimed to be asbestos power alone or mixed with other materials.

MOTOR TRUCKS

Bodies. Modern Motor-Truck Bodies, J. Walker. Soc. Automotive Engrs.—Jl., vol. 26, no. 3, Mar. 1930, pp. 372–374 and (discussion) 374–378, 7 figs. Some examples of aluminum bodies, which reduce deadweight and enable chassis to carry more pay load within maximum-weight restrictions of various States, are given, and methods of mounting tank and motor-coach bodies flexibility on chassis are illustrated and described.

Diesel (Mercedes-Benz). Mercedes-Benz Motor Trucks With Crude-Oil Engines (Mercedes-Benz-Laskraftwagen mit Rohoelmotor). Automobil-Rundschau (Berlin), vol. 32, no. 6, Mar. 15, 1930, pp. 112–116, 10 figs. Fuel employed in engines is either gas, oil or lignite-distillation product; description of truck with special details of engine, which is ante-chamber type of Diesel.

N

NOISE MEASUREMENT

Instrument for. Noise Recorder (Thorybometer) [Ein Laermzaehler (Thorybometer)], H. Dold and H. Thiele. Gesundheits-Ingenieur (Munich), vol. 53, no. 1, Jan. 4, 1930, pp. 13–14, 2 figs. Noise number is suggested as unit for noise measurements; noise recorder or thorybometer is equipment by which noise is measured by quantity of oxy-hydrogen gas electrically developed in accordance with noise produced.

P

PHOSPHOR BRONZE

See BEARING METALS.

PLANERS

Metal-Working, Reversing Gear for. Reversing Gear for Planing Machines. Engineering (Lond.), vol. 129, no. 3352, Apr. 11, 1930, pp. 476–477, 6 figs. Details of equipment made by Etablissements Charles Berthiez, Paris; principle employed is that of using comparatively small reversible motor to move table both on cutting and return strokes, and providing power necessary for cut by heavier motor running in one direction only and used only during cut.

PLATES

Stresses in. Web Stresses in Smooth Plates Subjected to Shearing Load (Ausbeulerscheinungen an ebenen auf Schub beanspruchten Platten), F. Bollenrath. Luftfahrtforschung (Munich), vol. 6, no. 1, Dec. 12, 1929, pp. 1–17, 37 figs. Results of tests on thin, plane, elastic plates fixed in two edges parallel to one another and subjected to load sheared in opposite direction but of equal forces, distributed equally over both edges. Bibliography.

POWER PLANTS

Cost Accounting in. Some Economic Fallacies in Isolated Power-Plant Cost Analyses, F. M. Van Deventer. Engrs.' Soc. of West. Penn.—Proc., vol. 46, no. 1, Jan. 1930, pp. 16–23 and (discussion) 24–33. Discussion of common fallacies in cost analysis and outline of accurate method of procedure; comparative tables illustrating total capital expenditure and yearly operating costs before and after rehabilitation of specific plant.

Instruments Readings, Interpretation of. Training in the Interpretation of Instrument Readings. World Power (Lond.), vol. 13, no. 76, Apr. 1930, pp. 386 and 389–392, 5 figs. Notes on necessity of training boiler-house personnel in correct interpretation of instrument readings is followed by reference to important part which control apparatus plays in textile industry; two handy forms of testing apparatus for carbon dioxide contents in flue gases are described and brief particulars are given of convenient smoke indicator for use of boiler operator.

PRESSES

400-Ton Crank Type. Gigantic Power Press of the Crank Type. Machy. (N. Y.), vol. 36, no. 8, Apr. 1930, pp. 637–638, 3 figs. Description of largest press of crank type ever built recently constructed by Toledo Machine and Tool Co., Toledo, Ohio; press is used for heavy blanking, forming, and piercing operations in manufacture of large truck rails and for other works of similar nature; total weight of press is 800,000 lb.; two large steel spur gears, one on each end of crankshaft are 140 in. in diam. and have 18-in. face.

Welded Construction. Presses and Shears Arc Welded, C. M. Taylor. Iron Age, vol. 125, no. 15, Apr. 10, 1930, pp. 1066–1078, 7 figs. Use of welding of steel plates and shapes in building up frames for large presses and shears which must be extremely strong and rigid; one press described has capacity of 1000 tons.

PRESSURE VESSELS

Electric Welding of. Arc Welding at a Large Boiler Works. Engineer, (Lond.), vol. 149, no. 3872, Mar. 28, 1930, pp. 344–345, 6 figs. Particulars of English Electric welding installation in Thompson Bros. tank shops at Bilston; examples are given of welding chemical vessel tested to pressure of 1500 lb. per sq. in.; and welded rotary drier; installation is composed of 12 welding sets, each consisting of 10-hp. squirrel-cage induction motor coupled to steel-frame welding generator capable of giving from 250 to 300 amperes at 30 volts.

PULVERIZED COAL

Firing With. Pulverized Fuel Firing, A. H. Hayes. World Power (Lond.), vol. 13, no. 76, Apr. 1930, pp. 382 and 385. Direct firing versus storage system; rise to prominence of pulverized-fuel firing for boilers has been accompanied by more or less constant controversy as to respective methods of dealing with fuel after grinding; survey of direct system and of storage system is made with view to ascertaining their relative methods for any given set of conditions.

PUMPS

Air-Lift. Conveying Materials by Means of Air-Lift Pumps, F. Schildberger. Eng. Progress (Berlin), vol. 11, no. 4, Apr. 1930, pp. 100–103, 7 figs. Air-lift pumps operate in manner similar to that of pneumatic conveyors for grain, coal, sawdust, and similar goods, though with difference that air used is under compression instead of under vacuum; although mechanical efficiency of air-lift pumps is low, their absolute operating dependability and all-round freedom from trouble have made them indispensable, particularly where rough operating conditions prevail; examples of practical application.

Water Hammer in Discharge Pipes. Water Hammer in Discharge Mains of Pumps (Druckstoesse in Pumpensteigleitungen), O. Schnyder. Schweizerische Bauzeitung (Zurich), vol. 94, nos. 22 and 23, Nov. 30, 1929, pp. 271–273, Dec. 7, 1929, pp. 283–286, 20 figs. Mathematical theory of water hammer in discharge pipes of pumps; charts for determination of pressure variations caused by sudden closure; features of special conical valves and other devices for minimizing water hammer, developed and manufactured by L. von Roll Eisenwerke Clus.

R

RAIL MOTOR CARS

Gasoline-Electric. A Typical Gas-Electric Car; Richmond, Fredericksburg and Potomac Railroad. Railroad Herald, vol. 34, no. 5, Apr.

1930, p. 23, 1 fig. **Brief** discussion of passenger and baggage gas-electric car in use by Richmond, Fredericksburg and Potomac Railroad; steel construction; double power plant; single end control; total length 73 ft. 4 in.; width over posts 9 ft. 10 in.; truck wheels 33 in. in diameter; total seating capacity 76.

Steam. Articulated Steam Rail Coach for Egypt. Engineer (Lond.), vol. 149, no. 3872, Mar. 28, 1930, pp. 348–349, 5 figs. Details of coaches made by Birmingham Railway Carriage and Wagon Co.; they are divided into two types, one having accommodation for second- and third-class passengers with baggage, 117 passengers all told; while other has accommodation for first-, second-, and third-class passengers; boiler is of "Yorkshire double loco" type; structure of coach is of mild steel throughout, underframe being built integral with body usual for steel cars.

New Articulated Steam Rail Cars for Egyptian State Railways. Ry. Gaz. (Lond.), vol. 52, no. 13, Mar. 28, 1930, pp. 475–478 and 480, 11 figs. Cars built by Birmingham Railway Carriage and Wagon Co.; engine is Yorkshire type; it is of three-cylinder vertical double-acting balanced type; cylinders are 5 ft. diam. by 8 in. stroke; steam distribution effected by Joy valve gear operating piston valves; engine develops 150 B.hp. on jack shaft at 38 m.p.h.; principal dimensions are length over cowcatchers 101 ft. 7 in.; engine truck wheelbase 7 ft.; weight on rail at engine truck 30 tons.

ROLLING MILLS

Aluminum, Electric Drive in. Massena Mill Relies Largely on Electrical Applications. Elec. World, vol. 95, no. 15, Apr. 12, 1930, pp. 742–746, 7 figs. Electric drive, control, recording, and furnaces are extensively used by Aluminum Company of America at its Massena, N. Y. mill; details of electric bloom-preheating ovens, control for 5000-hp. reversing blooming mill, bloom shear and 2000-hp. non-reversing structural rolling mill, 90-ft. electric heat-treating furnace, 110,000-kw. group of alumina-reducing pots, aluminum cranes, busbars, conductors, etc.

Continuous Sheet Mills. Straight-Line Making of Sheets, T. H. Gerkin. Iron Age, vol. 125, no. 15, Apr. 10, 1930, pp. 1064–1065, 2 figs. Layout of sheet mill of Newton Steel Co., Monroe, Mich., which utilizes mechanical handling devices for continuous production of sheets.

Energy Required in Rolling. The Rolling of Metals, J. S. Caswell. Engineer (Lond.), vol. 149, no. 3873, Apr. 4, 1930, pp. 369–371, 1 fig. Notes on actual energy requirements; friction in rolling mill; energy requirements for rolling of sections; coefficient of friction; total energy required to operate mill. (Concluded.)

S

SCREW THREADS

Gages. Improved Screw-Thread Measuring Equipment (Verbessertes Gewindemessgeraet), F. Goepel. Zeit. fuer Instrumentenkunde (Berlin), vol. 50, no. 1, Jan. 1930, pp. 33–42, 10 figs. partly on supp. plate. Measuring equipment described in Zeitschrift fuer Feinmechanik und Praezision, 1924, has been improved; improved equipment and its applications are described.

SHAPERS

Hydraulically Driven. Hydraulically Driven Shaping Machine. Engineer (Lond.), vol. 149, no. 3872, Mar. 28, 1930, p. 360, 2 figs. Details of new shaper by Lange and Geilen, of Halle, Germany; reciprocating head of machine is actuated directly by oil pressure, and oil pressure is also used for traverse of table, and serves as means of speed regulation; machine is driven primarily by flanged electric motor.

SHEET-METAL WORKING

Stamping. Flow Phenomena in Deep Drawing of Sheet Metal and Cause of Crack Formation in Stampings (Fliesserscheinungen bei Tiefstanzblechen, etc.), I. Fetschenko-Tschopiwski and M. Opalko. Zeit. des Oberschlesischen Berg. u. Huettenmaennischen Vereins Zu Katowice (Katowice), vol. 69, no. 4, Apr. 1930, pp. 182–184, 16 figs. on supp. plates. Flow lines appear on surface of sheet metal as result of process and these have influence on punching quality and crack formation by Erichsen tests; this test is not always dependable; supplementary test for determining stamping quality of materials is described.

SPRINGS

Helical. Designing Steel Springs for Two Loads, H. M. Brayton. Machy. (N. Y.), vol. 36, May 1930, pp. 679–682, 1 fig. Method of designing small springs when two loads and height of spring at which each load is applied are specified.

STEAM

Calorimetry of. Calorimetry of a Fluid, N. S. Osborne. Bur. of Standards—Jl. of Research, vol. 4, no. 5, May 1930, pp. 609–629. In this paper calorimetric method of determining thermodynamic characteristics of fluid is outlined; basic principles involved and application of method to formulation of thermal properties for engineering uses are analyzed; method has been developed at U. S. Bureau of Standards for determining properties of steam.

STEAM ACCUMULATORS

Peak-Load Uses of. Steam Storage in Its Relation to the Peak Load Problem in Industrial Steam Plant, E. G. Ritchie. S. Wales Inst. of Engrs.—Proc., vol. 46, no. 2, Mar. 13, 1930, pp. 69–89, 9 figs. Discussion of "bottle-neck" effect in industry; limitations of boiler equipment; effect of steam-pressure variations; thermal flywheel; Ruths steam-storage system; steam storage and industrial peak load; other systems of thermal storage; steam storage in steel works, and at coal mines; steam storage in relation to efficient operation of waste-heat boilers.

STEAM CONDENSERS

Corrosion. The Prevention of Trouble Due to Aquatic Growths in Condenser Systems, D. V. Onslow. World Power (Lond.), vol. 13, no. 76, Apr. 1930, pp. 379–381. Article is based on replies received by British Electrical and Allied Industries Research Association to their questionnaire sent to manufacturers of condensers and to large users of condensing plant with regard to troubles caused by accumulation of mussels and other aquatic growths in condenser tubes.

STEAM-ELECTRIC POWER PLANTS

Gorgas, Ala. Gorgas Expands in Separate Plant, J. M. Gallalee and R. M. Ferrill. Elec. World, vol. 95, no. 15, Apr. 12, 1930, pp. 732–738, 9 figs. Initial plant of Alabama Power Co. is 70,000 kw.; addition of 240,000 kw. housed in independent structure; will pulverize coal from nearby mine; pressure of 450 lb. and steam temperature of 725 deg. adopted; except for generators all electric equipment is outdoors; principal steam equipment in new Gorgas plant is specified.

Great Britain. The Extension Plant at Leicester. Elec. Times (Lond.), vol. 77, no. 2000, Feb. 20, 1930, pp. 373–377, 11 figs. New section will contain four water-tube boilers, two 25,000-kw. generating sets, two house service turbo-generator sets of 1500 kw. each; steam pressure is 350 lb. per sq. in. and there is no re-superheating; large boilers of 180,000 lb. per hour for two hours on overload are used together with steel tube economizers, Murray water-tube walls and ashpit water screen; coal storage and reclaiming plant, new 25,000-kw. English Electric turbo set and exciter, switchgear etc., are illustrated.

Reconstruction of Lots Road Power Station. Engineering (Lond.), vol. 129, no. 3351, Apr. 4, 1930, pp. 443–444, 2 figs. Account of reconstruction of station in Chelsea from which most of electric energy required for London underground railways is derived; four cross-drum marine-type boilers, with output of 50,000 lb. of steam each, and operating at 200 lb. and 700 deg. fahr., were erected; three of 6000-kw. sets have been removed, their place being taken by equal number of 15,000-kw. machines; further 15,000-kw. unit is in course of erection; as result of this reconstruction, capacity of station will be raised from 48,000 to 105,000 kw.

Milwaukee. Lakeside's Second High-Pressure Unit, T. Wilson. Power, vol. 71, no. 16, Apr. 22, 1930, pp. 618–621, 7 figs. Station's nine-year record of operating economy is expected to be further enhanced by added 1300 lb. unit; feedwater flow and steam flow are maintained coincident; water level checked by means of periscope; flue gas mill drying improves boiler room efficiency and reduces investment.

STEAM ENGINES

Traction Type. The Development of the Locomobile, H. Scharbau. Eng. Progress (Berlin), vol. 11, no. 1, Jan. 1930, pp. 1–4, 9 figs. Review of development from early model to modern superheated type; modern locomobile for combined power and heat supply.

Uniflow. New Vertical Unaflow Engine. Plant Eng., vol. 34, no. 8, Apr. 15, 1930, pp. 464–466, 5 figs. Illustrated discussion of skinner 3-cylinder, vertical uniflow engine equipped with expansion-compensating, double-seat poppet admission valves; sectional and end elevation views are given; description of valve arrangement and operation.

STEAM PIPE LINES

Expansion in. Study of Design of Steam Pipe Line With Regard to Expansion (Etude d'un tracé de tuyauterie à vapeur au point de vue de la dilatation) H. Carlier. Chaleur et Industrie (Paris), vol. 11, no. 120, Apr. 1930, pp. 174–177, 13 figs. Study of elastic deformations; importance of investigation of supports is set forth.

High-Pressure. Measurement of Fatigue of High-Pressure Steam Pipe Lines (La mesure de la fatigue des tuyauteries de vapeur à haute pression), F. L. Atthalin. Technique Moderne (Paris), vol. 22, no. 8, Apr. 15, 1930, pp. 274–278, 10 figs. Experimental study of additional strength due to oval shape of cross-section in bends; results of tests are recommended for application in 44-kg., 450-deg. cent. pipe-line system in Issy-les-Moulineaux power plant.

STEAM POWER PLANTS

High-Pressure. High Pressure and Temperature in Power Generation, G. A. Orrok. World Power (Lond.), vol. 13, no. 74, Feb. 1930, pp. 185–186 and 189. Article deals with progress in thermal efficiency of central stations; emphasizes reasons and itemizes causes which have brought gratifying results; indications of commercial efficiency as compared with thermal efficiency are given and progress in system economy through interconnection and community interest is stressed. Paper presented before World Power Conference, Tokyo.

The Power Plant of I.C.I., Ltd., H. A. Humphrey, D. M. Buist, and J. W. Babsall. Elec. Rev. (Lond.), vol. 106, no. 2730, Mar. 21, 1930, pp. 562–563 and (discussion) 563. Account of pulverized-fuel, high-pressure, high-temperature, industrial plant installed by Imperial Chemical Industries, Ltd., for supplying steam and electricity to Billingham-on-Tees factory of Synthetic Ammonia and Nitrates, Ltd.; steam pressure is 800 lb. per sq. in. gage; maximum temperature of 856 deg. fahr. Extracts from paper read before Instn. Elec. Engrs.

Industrial, Costs. Capital Costs of Steam Power Plants (Die Kapitalkosten von Dampfkraftanlagen), H. C. Eberle. Archiv. fuer Waermewirtschaft (Berlin), vol. 11, no. 3, Mar. 1930, pp. 65–68. Notes on evaluation of capital costs in calculation of economy of new industrial plants with regard to steam and power generating plants.

Industrial, Design. Trend in Design and Operation of Industrial Plants With Special Reference to Furnace Volume, H. Kreisinger. Engrs.' Soc. of West. Penn.—Proc., vol. 45, no. 9, Dec. 1929, pp. 426–440 and (discussion) 441–450, 5 figs. Trend in industrial plants is toward larger steam-generating units; special advantages of high pressures; discussion of fuels burned, furnace design, and process of combustion.

STEAM TURBINES

Marine. The Design of Single-Reduction Gearing for Compound Turbines, T. Gardner. Engineering (Lond.), vol. 129, no. 3353, Apr. 18, 1930, pp. 500–502. Notes refer to usual arrangement of geared steam turbines, such as are used in high-powered destroyers or flotilla leaders in which reduction of weight to minimum combined with maximum loading of power elements, is primary consideration.

STEEL

Annealing. The Gruenewald Bright Annealing Process. Engineering (Lond.), vol. 129, no. 3351, Apr. 4, 1930, p. 442, 3 figs. Plant embodies principle which is result of exhaustive investigation into possibility of carrying out this form of treatment on rather simpler lines than have hitherto been usual; contact of atmospheric oxygen with heated material is prevented by simple and convenient method described.

Deoxidation. Deoxidation in the Making of Steel, J. R. Miller. Iron Age, vol. 125, no. 17, Apr. 24, 1930, pp. 1223–1224, 1 fig. Brief discussion of use of oxidizing agents; methods for removing injurious oxides and limiting internal cavities; possibilities of controlling location of blowholes.

Chromium. See CHROMIUM STEEL.

Chromium-Copper. See CHROMIUM-COPPER STEEL.

Cold Drawing. Selection of Sheet Steel for Deep Drawing, W. H. Graves. Am. Mach., vol. 72, no. 18, May 1, 1930, pp. 718–719, 3 figs. Criteria for workability and physical properties discussed; Erichsen and Rockwell tests for no. 19 gage steel; specifications of steel for extra deep drawing and deep drawing recommended.

Creep at High Temperatures. Creep of Steel at High Temperatures, F. H. Norton. Brit. Non-Ferrous Metals Research Ass.—Bul., no. 28, Mar. 1930, pp. 15–18. Author's object is to provide engineers with data on safe stresses for various steels, especially at high temperatures.

Manufacture—Duplex Process. Duplex Practice, J. E. Carlin. Am. Soc. Steel Treating—Trans., vol. 17, no. 5, May 1930, pp. 631–637. Article is prompted by fact that duplex process enbodies two features whose successful utilization will very materially assist in changing basic open-hearth process from art to science; these two features are change of slag by use of tilting furnace and deoxidation with carbon; as long as slag contains iron oxide, oxidation is predominant; if oxidizing slag is replaced by neutral one made up of lime and spar, it should be possible to reduce remaining oxide by residual or additional carbon.

Manufacture—Musso Process. The Musso Steel Process, C. E. Parsons. Iron and Steel of Canada (Gardenvale, Que.), vol. 13, no. 4, Apr. 1929, pp. 73–74 and 93 and 95, 2 figs. Operation and equipment of Ottawa Plant of Musso Steel Process, Ltd., of Canada; cost-reducing features of process; coal required is but 40 per cent of that used in blast-furnace and open-hearth methods; cost of ingot steel with Musso process will be 20 per cent less than cost of open-hearth ingots; quality will be equal to high-grade electric steel; process diagram and heat-flow plan given.

Nitrided, Annealing of. Annealing or Softening of Nitrided Steels by Chemical Decomposition of the Nitrides, W. J. Merten. Am. Soc. Steel Treating—Trans., vol. 17, no. 5, May 1930, pp. 638–644 and (discussion), 644–645, 4 figs. Method of softening nitrided case of aluminum-molybdenum and aluminum-chromium nitriding steels by chemical decomposition of nitrides in fused sodium-potassium chloride bath; temperature of bath is low; points out service conditions under which nitrided steel parts do not perform satisfactorily since, due to atmospheric conditions, deterioration by chemical reactions are inevitable.

Quenching. A Study of the Quenching of Steels, H. J. French. Am. Soc. Steel Treating—Trans., vol. 17, no. 5, May 1930, pp. 646–727, and (discussion) 728–730, 54 figs. Paper is based upon researches carried out by author and former associates at U. S. Bureau of Standards; description of test methods; characteristics of cooling curves obtained in different coolants; effects of size and shape of sample upon cooling of steels; consideration is given to both center and surface cooling in different coolants, and data for center cooling are summarized graphically and in equations.

STEEL CASTINGS

Alloy-Steel. Alloyed Steel Castings in Theory and Practice (Legierter Stahlguss in Theorie und Praxis), A. Rys. Stahl und Eisen (Duesseldorf), vol. 50, no. 14, Apr. 3, 1930, pp. 423–438, 56 figs. Improvements of ingot steel to meet present mechanical, physical, and chemical requirements, by addition of alloying elements; investigation of different alloy-steel castings to determine strength, high-temperature resistance, effect of heat treatment, endurance, corrosion resistance, impact hardness, etc.; magnetic and non-magnetic acid- and heat-resisting steels.

Heat Treatment of. Continuous Equipment for Heat-Treating Steel Castings, A. C. Jones. Fuels and Furnaces, vol. 8, no. 4, Apr. 1930, pp. 475–478, 4 figs. Two continuous, oil-fired, pusher-type furnaces used in heat-treating steel castings; heat to 1650 deg. fahr., quench in air and draw at 1225 deg. fahr.

Machinability. Steel Castings and Their Machinability (Stahlguss und Zerspanbarkeit), A. Wallichs and K. Krekeler. Giesserei (Duesseldorf), vol. 17, no. 14, Apr. 4, 1930, pp. 325–329, 10 figs. Steel castings of today are subjected to thorough tests to determine their machinability; account of tests carried out by Aachen machine tool laboratory on standard steel castings 38.81, 50.81, 60.81, and on nickel and chromium-nickel alloys; influence of melting, and of carbon and silicon content.

Temperature Effect. Strength of Steel Castings at Elevated Temperature With Special Regard to Influence of Nickel (Die Dauerstandfestigheit von Stahlguss bei erhoehten Temperaturen), A. Thum and H. Holdt. Giesserei (Dusseldorf), vol. 17, no. 14, Apr. 4, 1930, pp. 333–339, 10 figs. Results of tests on steel castings with varying nickel content in annealed and unannealed state to determine impact and notch hardness, tensile strength, elastic limit, elongation and shrinkage at temperatures ranging from 20 to 500 deg. cent.; nickel content up to 1.5 per cent improves all properties.

High-Temperature Resistance of Steel Castings With Small Admixtures of Nickel and Molybdenum (Ueber die Warmfestigkeit von Stahlguss mit geringen Zusaetzen von Nickel und Molybdaen), W. Liestmann and C. Salzmann. Stahl und Eisen (Duesseldorf), vol. 50, no. 14, Apr. 3, 1930, pp. 442–446, 14 figs. Tests were carried out on castings with increasing additions of nickel (0.4 to 2.2 per cent) and molybdenum (0.2 to 0.6 per cent), to determine tensile strength, elastic limit, elongation, and shrinkage at 500 deg. cent.

STEEL FOUNDING

Copper Molds. The Casting of Steel in a Water-Cooled Copper Ingot Mould, W. Oertel. Iron and Steel Industry (Lond.), vol. 3, no. 5, Feb. 1930, pp. 137–139 and (discussion) 140–141, 8 figs. Paper deals with investigation of properties of some steels cast in water-cooled copper ingot molds, including mechanical strength, crystalline structure, and, to some extent, hardness ranges of quenched specimens; number of times specimens could be quenched without cracking, and resulting magnetic properties, are also dealt with. Abstract of report no. 145, of Verein duetscher Eisenhuettenleute, indexed in Engineering Index 1929, p. 1772, from Stahl u. Eisen, May 9.

Plant for Large Castings. Plant for Making Large Steel Castings, C. Longenecker. Blast Furnace and Steel Plant, vol. 18, no. 4, Apr. 1930, pp. 622–623 and 626, 5 figs. Description of plants of Ohio Steel Foundry Co., Lima and Springfield, Ohio; at Springfield plant, steel is melted in electric furnaces; at Lima, melting is done in open hearth furnaces; metal of which castings are composed is either straight carbon or alloy steel; output of Lima plant is approximately 2200 tons of castings per month; smaller castings are manufactured at Springfield plant which has monthly capacity of 600 tons of small electric steel castings and 100 tons of heat and corrosion-resisting castings.

Rustless Castings. Make Rustless Steel Castings. Iron Age, vol. 125, no. 14, Apr. 3, 1930, pp. 993–996, 6 figs. Specialized foundry for manufacture of heat-resisting alloy castings, designed as model plant built by Ohio Steel Foundry Co. at Springfield, Ohio; foundry has capacity of 100 tons of castings per month; centrifugal castings machine, designed by company, for making pipe 4 to 16 in. in diam., is included in equipment; foundry building is steel frame structure 200 ft. long and 100 ft. wide; melting is done in 1-ton standard type Swindell electric furnace; usual furnace heat is 2500 lb.; gas-fired ovens dry molds and cores.

STOKERS

Traveling-Grate. Recent Developments in Traveling-Grate Stokers (Die neuere Entwicklung der Wanderrostfeuerung), Presser. Archiv fuer Waermewirtschaft (Berlin), vol. 11, no. 4, Apr. 1930, pp. 131–136, 18 figs. Review of recent improvements; chain-grate stoker and experiences made with it outside of Germany; results obtained with forced-draft zone grate, and suggestions for improvement; influence of coal burned per unit grate area on temperature of firebars; prospects for traveling-grate stokers.

SUPERHEATERS

High-Temperature. Superheaters for High Steam Temperatures (Ueberhitzer fuer hohe Dampftemperaturen), W. Orth. Waerme (Berlin), vol. 53, no. 12, Mar. 22, 1930, pp. 227–229, 7 figs. New method is described showing that superheater tubes of SM steel are subject to internal corrosion even when steam is free from impurities and air, when steam temperatures of 500 deg. cent. is exceeded; suggestions are given for design of superheaters for steam temperatures.

T

THERMODYNAMICS

Static. Reflections on Static Thermodynamics (Réflexions sur la thermodynamique statique), J. H. Coblyn. Chaleur et Industrie (Paris), vol. 11, nos. 117, 118, and 119, Jan. 1930, pp. 31–38, Feb. 99–108, and Mar. 141–146, 3 figs. Jan.: Research of Amagat on thermometric similitude of liquid vapors; analytical study in neighborhood of critical point; entropy curves. Feb.: Critical tables for carbon-anhydride, ammonia, sulphur anhydride, ethane, ethylene, methyl chloride, etc. Mar.: Critical tables of carbon monoxide, chlorine, oxygen, nitrogen, argon, xenon, neon, hydrogen, and helium.

TRACTORS

Manufacture of. All-Modern Equipment Produces Allis-Chalmers Tractor, W. Watson. Am. Mach., vol. 72, no. 11, Mar. 13, 1930, pp. 436–443, 13 figs. Description of machine tools used in new Allis-Chalmers Manufacturing Co. designed for production of 50 Model U tractors per day; special-purpose equipment and tooling predominate; analysis of equipment employed on different operations is given; layout of floor plans; transportation of parts by means of Louden overhead monorail system.

TUBES

Cold-Working. Study of Cold-Worked, Thick-Walled Tubes With Special Regard to Changes in Properties of Materials (Untersuchungen an kaltgereckten, dickwandigen Rohren, unter besonderer Beruecksichtigung der Veraenderungen der Werkstoffeigenschaften), H. Klein. Mitteilungen aus dem Wilhelm-Institute fuer Eisenforschung (Duesseldorf), vol. 11, no. 20, 1929, pp. 331–341, 13 figs. Theory of thick-walled hollow cylinders; calculation of stresses in such cylinders for elastic failure of materials; tests were carried out on specimen tubes of nickel-chromium and nickel-tungsten steel and of unalloyed steel.

TURBO-GENERATORS

Breakdown of. Mechanical Degree of Safety in Large Turbo-Generators, H. Ricklu. Engineering (Lond.), vol. 129, no. 3350, Mar. 28, 1930, pp. 421–423, 4 figs. Serious accidents to 3000-r.p.m. turbo-rotors have been reported during last two years; some of these have occurred at as early a stage as during overspeed tests at works in question, and others after plant had been in operation, sometimes after long period of service; cause of breakdowns appears to reside in certain properties of material. Abstract of paper read before World Power Conference in Tokyo.

W

WAGES

Payment Plans. Oakland Wage Incentive System Promises Savings in Overhead, J. Geschelin. Automotive Industries, vol. 62, no. 15, Apr. 12, 1930, pp. 576–579, and 584, 4 figs. Experimental work in materials-handling group inaugurates plan to apply bonus method to non-productive or indirect labor; combined unit efficiency is measured in terms of direct labor payroll.

Payment Plans. Wage Incentives in Manufacturing, D. B. Kift. Iron Age, vol. 125, no. 11, Mar. 13, 1930, pp. 786 and 836. Discussion of management factors and responsibilites preliminary to and coincident with installation and operation of wage incentives. Abstract of paper read before Chicago meeting of Am. Soc. Mech. Engrs.

WELDING

Structural Steel. Application of Arc Welding to Machine Design and Building Construction, A. M. Candy. Am. Welding Soc.—Jl., vol. 9, no. 3, Mar. 1930, pp. 66–73, 5 figs. Examples of application of arc welding in fabrication of turbo-generator, motor buses, roof truss; advantages of arc welding.

WELDS

Stresses in. The Theory of Stresses in Welds, L. C. Bibber. Am. Welding Soc.—Jl., vol. 9, no. 4, Apr. 1930, pp. 104–137, 36 figs. Certain theories regarding strength of welds as affected by quantity and disposition of weld metal; design data and tables that will enable designers and draftsmen to use this information.

WIND TUNNELS

United States. The U. S. Wind Tunnels, R. M. Wood. Aircraft Eng. (Lond.), vol. 2, no. 12, Feb. 1930, pp. 42–44, 3 figs. Author points out necessity for full-scale tunnels, and describes development of halfway stage and full-scale open-jet tunnels developed by National Advisory Committee for Aeronautics; he proposes design which follows closely Goettingen tunnel but with overall dimensions much reduced; there is at Wright Field another interesting tunnel which may be called "full-speed" tunnel, of highly efficient Venturi form and attains speed of 275 m.p.h. Lecture before Royal Aeronautical Soc.

WIRE

Machines for Forming. Wire and Strip Metal Forming Machines. Machy. Market (Lond.), no. 1537, Apr. 18, 1930, p. 21, 2 figs. Description of improved four-slide automatic wire-forming machine and single-blow cold-heading machine built by E. White of Windsor Works, Redditch; machine will head wire up to 2½ times diameter of wire at single blow.

WOODWORKING PLANTS

Cost Accounting. Cost Systems for Wood-Working Factories, C. F. Scribner. Woodworker, vol. 48, no. 12, Feb. 1930, pp. 52–54. Majority of industrial owners and manufacturers do not comprehend value of complete and exact cost system; results summarized; material and stores control.

IN TWO SECTIONS—SECTION TWO

MECHANICAL ENGINEERING

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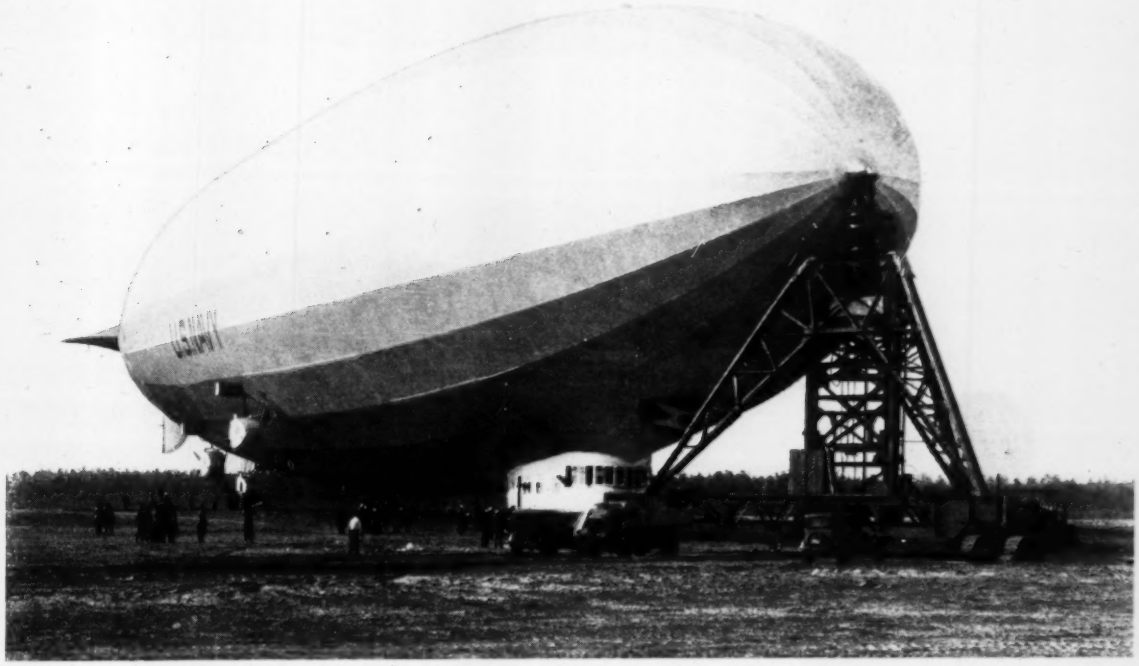


AIRSHIP MOORING MAST

When the *Graf Zeppelin* came to this country recently it made use of the new mobile mooring mast at Lakehurst. "With the new mast," says a dispatch in the New York *Times*, "the largest dirigible may be pulled down and made fast in a twenty-mile-an-hour cross-wind, and the operation may be performed with greater speed and safety than formerly was possible with a ground crew of 400 men hauling away at hawsers dropped from a large airship." By means of the tractor the stub mast may be drawn into the hangar when it is desired to berth the ship. Photo courtesy Navy Recruiting Bureau, New York.

What It's All About

THE papers published in MECHANICAL ENGINEERING represent the careful studies of men who are experts in their fields. These men put the results of their work into the literature of engineering so that others may profit by it and be saved the trouble of repeating their researches. This supplement to MECHANICAL ENGINEERING comments briefly on the contributions to the July issue so that the busy reader may know "What it's all about."

The Gas Turbine

THERE are two types of machines known as gas turbines, and it is necessary to distinguish between them. One is essentially an internal-combustion engine, burning its own fuel and absorbing the energy of the gases by means of a rotor, and the other is an appendage to a reciprocating engine, utilizing the energy that remains in exhaust gases, and hence known as an exhaust-gas turbine. Gas turbines of the second type have been developed to drive superchargers for Diesel, automobile, and aeronautical engines. They are in daily use. The design problems they present have not been especially difficult, and they have been justified on economic and thermodynamic grounds. Not so the first type, which are prime movers. Inventors have worked on this type of gas turbine for years in attempts to find a practical solution to its difficulties. For maximum efficiency the temperatures in the gas turbine are so high that it has been difficult to find materials that will withstand them. Of the fundamental combustion processes, constant-pressure and constant-volume, the first, of which the turbine of Armengaud and Lemale was an early example, requires some means for compressing the combustion air. The compressor absorbs a considerable amount of the power generated. The second, of which the Holzwarth gas turbine is typical, involves valves for admitting the combustion gases to the turbine rotor.

With the development of the aeronautical engine and

Official Photograph, U. S. Army Air Corps

GYROSCOPES PILOT 10-TON BOMBER

Lt. Marion Huggins, 96th Squadron, 2nd Bombardment Group (left), with Elmer A. Sperry, Jr., inventor, showing the two gyroscopes that guide the 10-ton Army Air Corps bombardment plane with greater accuracy than the best-trained pilot.

the Diesel engine, the exhaust-gas turbine has received the attention of engineers as a means of driving the supercharger. Familiar in this connection are the names of Moss, Rateau, Büchi, and Lorenzen. Success has been more easily attained in this field inasmuch as the temperature of the exhaust gases is not as high as that in the combustion chamber, and because it has not been necessary to provide a compressor to supply the air for combustion. Experience acquired with the supercharger has naturally led designers to attempt again the development of the gas turbine as a prime mover, with the result that at least one successful exhaust-gas supercharger has become the basis for a "pure" or "live" gas turbine. This machine is a development by Christian Lorenzen, of Berlin, and is described in the July issue of MECHANICAL ENGINEERING in a paper entitled "The Lorenzen Gas Turbine and Supercharger for Gasoline and Diesel Engines."

The unique feature of the Lorenzen gas turbine is the means by which the rotor is cooled and the combustion air compressed and heated. The rotor of the turbine is so constructed that it serves also as the rotor of the air compressor. The air for combustion, drawn in at the center of the rotor, passes radially through it and the turbine blades, thus serving to cool the latter, while it in turn is compressed and heated for combustion purposes. The paper was presented at the Oil and Gas Power Conference at State College, Pa., in June, and contains many details of the supercharger and the turbine.

Modern Steam Turbines

THERE is only one way to find out what a useful paper Prof. A. G. Christie has prepared for the Second World Power Conference at Berlin on the subject of modern steam turbines, and that is to read it. The first instalment is in the July issue of MECHANICAL ENGINEERING. In order to indicate what it is like a few random sentences that are typical of paragraph after paragraph of the complete paper are quoted.

"No manufacturer furnishes the most efficient turbine that he is capable of building, with the possible exception of certain large special units. Each builder will supply at the current market price a turbine of about the same thermal efficiency as his competitors. This condition leads to low turbine prices."

"It would have been next to impossible to meet the power requirements that now exist in large electrical systems with reciprocating, gas, or Diesel engines."

"The capacity of a new unit should be such that in case of outage the remaining units of the system can safely carry the load. Recent practice indicates that the size of new units varies between one-sixth and one-fourth of the system's total capacity."

"Turbines are now generally selected on the basis of the average annual use factor over their working life, rather than on high use factors that may only be obtained during the first years of service."

"Central-station engineers sacrifice some measure of efficiency to secure rugged and dependable turbines. Refinements in design which may lessen dependability are subject to critical study before they are incorporated in new units."

"The major causes of turbine outages are blade troubles."

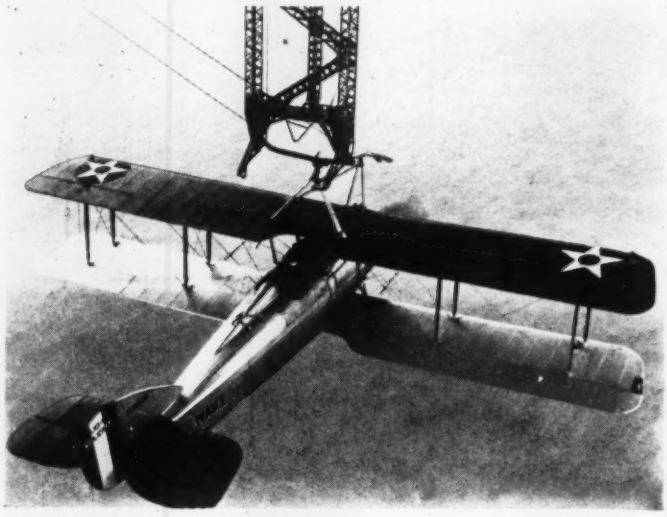
"Operators of 1200-lb. turbines state that there is no more difficulty in handling them in regular service than in operating standard units."

"The cost of a turbine for a given speed varies in general with the area of the last row of blades, for the high-pressure blading can usually be modified as desired with little change in total cost."

More next month.

Tungsten Carbide Tools

TUNGSTEN CARBIDE is one of those spectacular materials provided by modern research. As a material for cutting tools it appeared on the horizon of



AIRPLANE MOORED TO AN AIRSHIP

A UO-1 Vought biplane, showing latest mechanical device or "mooring bar" for hooking on to the dirigible U.S.S. *Los Angeles* while in flight. This device was developed entirely by American personnel. Its practicability was recently demonstrated in the Presidential Review when a plane took off from the deck of the U.S.S. *Saratoga*, attached itself to the U.S.S. *Los Angeles*, and later returned to the deck of the airplane carrier. The photo shows the airplane hooked to the mooring bar which extends below the airship. Photo courtesy of Navy Recruiting Bureau, New York.

the machine shop like a new and unknown comet, that swept rapidly within the vision of humble shopmen so that now it has become a major topic of their discussions. Impressed by the brilliant light of the publicity attending its appearance, but not knowing how to reckon its effects upon their technique, users of metal-cutting tools have been making a careful study of its possibilities, and manufacturers who have just succeeded in giving their machine tools the necessary rigidity to utilize to the fullest advantage the high-speed and alloy steels introduced thirty years ago, are earnestly investigating the probable effects of the new material upon their designs.

The fact that tungsten carbide will cut glass and porcelain does not interest particularly a worker in cast iron, or brass, or steel; but when he finds that the sand-filled skin of a casting does not seriously dull the tool, that castings too hard to be cut by other tools can be machined with tungsten carbide, that speeds can be advanced so that the amount of metal removed over a given period can be increased up to the limit of the driving power of the motor, that tools stay sharp much longer and hence require less frequent changing, grinding, or setting, and that production is materially increased; then, in spite of the fact that changes in methods and machinery may be necessary and that the new material is costly, the forward looking production manager must find out how his own problems are affected.

Addresses at the Second World Power Conference, Berlin, Could Be Heard Simultaneously in Several Languages by Means of a Telephonic and Interpreter System With Headsets for Every Person in the Audience

Therefore, cooperatively by committee investigation, and singly in individual plants, engineers have been finding out about tungsten carbide. At the Detroit meeting of the A.S.M.E. in June, much attention was given to reports on this new material. Two of the papers read at this meeting are published in the July issue of Mechanical Engineering. In one of these Coleman Sellers, 3rd, writes of the experience of the Wm. Sellers & Co., Inc., in the use of tungsten carbide in a paper entitled "Tungsten Carbide as a Cutting Material on Heavy Machine Tools."

Mr. Sellers describes the steps taken to introduce tungsten carbide tools into a machine shop and the method used to follow up the results obtained. He found that grinding was an important feature in the successful use of the material. He describes the types of tools used and comments upon them.

The experiences that Mr. Sellers reports cover the failures as well as the successes of the new material. Its advantages, in so far as cutting cast iron is concerned, are: More metal is removed in a given time; scale up to a hardness of 700 can be cut; hard castings may be salvaged without remelting; the tool retains its size through the entire operation involving a long cut. The disadvantages: The cost is high; the material is brittle and must be carefully handled; and no increased production is possible if the limit of the capacity of the machine has already been reached by using other tools.

Further testimony is provided by C. M. Thompson, of Henry Disston & Sons, Inc., who writes on "The Application of Tungsten Carbide to Circular Saws." In a comparison of the cutting time, using tungsten carbide-tipped teeth and high-speed-tool-steel teeth, it was found that with the former, armor plate $^{9}/_{16}$ in. thick could be cut at the rate of 0.682 ft. per hour, while with the latter, plate of the same material and $^{5}/_{8}$ in. thick was cut at the rate of 0.435 ft. per hour. With a copper-tin alloy $^{1}/_{4}$ in. thick, the rates were 186 and 36.5 ft. per hour, respectively.

Three Languages at One Time

BY MEANS of technically trained interpreters, microphones, and individual headsets for every person in the audience, it was possible to hear the papers and discussions at the World Power Conference in French, German, or English, as the listener desired. The accompanying sketch indicates how this was accomplished.

Placed in front of each seat in the auditorium was a pair of headphones connected to a switch by means of which the listener could select the language he best understood. The speakers and the interpreters, who translated on the spot, spoke into microphones equipped with soundproof mouthpieces. The speech currents were transmitted to an amplifier, and then to the switch boxes of the listeners.

In order to show which language might be heard at any given time, an indicator was arranged behind the speaker's rostrum with colored lamps which lighted up in accordance with the number of languages in which the speech was to be transmitted. A similar board was arranged at the amplifier apparatus to indicate which amplifier was required.

In addition to the three official languages of the Conference, the apparatus was designed so that two other languages could be used. Since the original speaker himself also spoke into a microphone, the apparatus had a capacity of six languages.

Where possible, addresses and reports were translated in advance. When this was not feasible, such as in the discussions, a specially trained staff of interpreters were employed, working in relays so as to maintain the continuity of the debate.

Second World Power Conference

AS THE July issue of Mechanical Engineering goes into the mails, the Second World Power Conference comes to a close in Berlin. This international gathering of engineers and economists is not devoted to power in the military sense, and is not a peace or dis-

armament conference. It concerns mechanical power that in the last two hundred years, and particularly in the last fifty years, has performed much of man's work for him, has increased his productivity, and has emancipated him from the oppressive burden of physical labor. It is this power that has created an industrial civilization, in which, because of their novelty and apparent desirability, and because they are so readily produced, things have received more attention than values.

There are three broad aspects in which problems of industrial power are discussed. Engineers confine themselves, as a rule, to the technological aspects of power. Here is a structure of hard fact which suits the natures of engineers. It towers starkly without sign of sentiment and emotion, and almost devoid of the prejudices of personal opinion. The second aspect is the economic one in which engineers take an increasing interest. But here, because they find fewer facts, wider influences, and more subtle implications, they seldom consider more than the well-known economics of commerce. To the third aspect of power, engineers pay scant heed. Perhaps it is not on them that social problems should be laid. Perhaps they prefer to remain the instruments by which some greater craftsmen may fashion civilization to human needs and ideals. Thus, in the papers read at the Second World Power Conference, technology and economics quite naturally overshadow their social implications. Four of the papers read at Berlin are to be found in the July issue of MECHANICAL ENGINEERING.

All four of these papers were prepared by engineers in the United States. One of them, already referred to, deals with the important subject of steam turbines, and was presented by a well-known authority. The others are devoted to heat transmission and heat insulation.

Heat Transmission

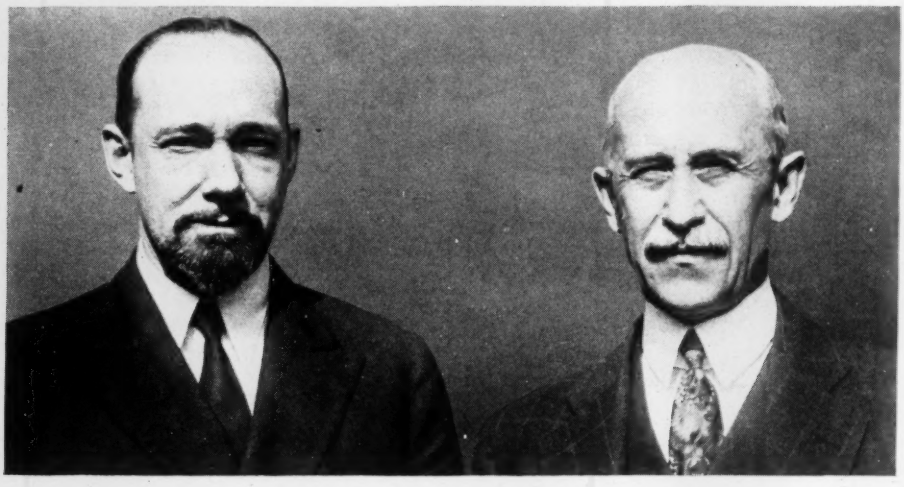
FIGURING how much heating or cooling surface is required is one of the commonest of engineering problems. Too much is costly, too little fails to accomplish the result. Consequently engineers and scientists have been striving for years to devise a theory of heat transmission that will give satisfactory results in design, and have collected data covering a wide variety of cases from which empirical relations may be derived and constants determined.

A group of three papers on researches in heat transmission and insulation by individual members of the Committee on Heat Transmission formed under the Division of Engineering and Industrial Research of the National Research Council, was presented at the Second World Power Conference, and are reprinted in the July issue of MECHANICAL ENGINEERING.

Prof. W. H. McAdams, of M.I.T., deals primarily with the individual coefficients of heat transmission between solids and fluids. He discusses the three classical methods of attack: (1) The mathematical, based on the differential equations of hydrodynamics and heat conduction: (2) the Reynolds analogy between heat transfer and fluid function; and (3) dimensional analysis.

H. C. Hottel, professor of fuel and gas engineering at M.I.T., in discussing radiant-heat transmission, deals briefly with the status of the subject, including recent developments. He also indicates wherein the knowledge of the subject is incomplete, and reviews briefly present activities in this field of research in America.

R. H. Heilman, senior industrial fellow, Mellon Institute of Industrial Research, Pittsburgh, Pa., discusses the relative importance of three modes of heat transmission—conduction, radiation, and convection—as applied to heat insulation.



PROMINENT FIGURES AT DAYTON AERONAUTIC MEETING

Captain Sir Hubert Wilkins, explorer of arctic regions by airplane, and Orville Wright, who, with his brother Wilbur, made mechanical flight in heavier-than-air craft possible, photographed together at the Dayton Meeting, May 19 to 22, of the A.S.M.E. Aeronautic Division.